MALACOLOGIA, 2009, 51(2): 233–261

NORTH PACIFIC SPECIES OF THE GENUS *SOLEMYA* LAMARCK, 1818 (BIVALVIA: SOLEMYIDAE), WITH NOTES ON *ACHARAX JOHNSONI* (DALL, 1891)

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ABSTRACT

North Pacific species of the family Solemyidae – *Petrasma pusilla* (Gould, 1861); *Solemya valvulus* Carpenter, 1864; *Solemya panamensis* Dall, 1908; *Petrasma pervernicosa* (Kuroda, 1948); *Solemya reidi* Bernard, 1980; and *Solemya tagiri* Okutani, Hashimoto & Miura, 2003 – and the type species of subgenera of the genus *Solemya* Lamarck, 1818, are re-examined. Five species of the genus *Solemya* are recognized from the North Pacific: *Solemya* (*Solemya*) *pusilla* (Gould, 1861); *Solemya* (*Solemya*) *valvulus* Carpenter, 1864; *Solemya* (*Solemya*) *tagiri* Okutani, Hashimoto & Miura, 2003; *Solemya* (*Petrasma*) *panamensis* Dall, 1908; and *Solemya* (*Petrasma*) *pervernicosa* Kuroda, 1948. The gutless *S. reidi* from the northeastern Pacific is synonymized with *S. pervernicosa* from the northwestern Pacific. *Solemya pervernicosa* was found in the Sea of Okhotsk and in the Sea of Japan near the coast of Sakhalin Island at the 300–800 m depth and was not previously recorded for Russia. A study of the materials of *Acharax johnsoni* (Dall, 1891) provided additional data on its distribution and ecology in the Pacific Ocean. This species was found in the Sea of Okhotsk (depth 370–1,515 m), as well as in the Monterey Canyon and Peru-Chile Trench (depth 3,040–4,200 m) in cold methane seep areas. The results of a comparative analysis of subgenera and species of the genus *Solemya*, descriptions of North Pacific species of the genus *Solemya*, and additional data on the distribution and ecology of *A. johnsoni* are presented.

Key words: *Solemya, Acharax,* systematics, morphology, distribution, cold seeps, Pacific Ocean.

INTRODUCTION

Representatives of the family Solemyidae are widely distributed in the North Pacific. To date, eight species of the Solemyidae are known for the North Pacific. On the coast of Japan, five species of this family have been reported: *Acharax johnsoni* (Dall, 1891), *Acharax japonica* (Dunker, 1882), *Petrasma pervernicosa* (Kuroda, 1948), *Petrasma pusilla* (Gould, 1861), and *Solemya tagiri* Okutani, Hashimoto & Miura, 2003 (Habe, 1977; Okutani, 2000; Okutani et al., 2003). In the northeastern Pacific, four species have been recorded: *A. johnsoni, Solemya reidi* Bernard, 1980; *Solemya panamensis* Dall, 1908; and *Solemya valvulus* (Carpenter, 1864) (Bernard, 1983; Coan et al., 2000). Nevertheless, in the Pacific seas of Russia, despite the neighborhood of coastal waters of Japan and North America, only *A. johnsoni* was recorded in the Bering Sea (Cape Olyutorski, depth 600–800 m, fresh valves) (Kafanov & Lutaenko, 1997). Also, Sahling et al. (2003) reported on the finding of *Acharax* sp. on the northeast Sakhalin slope and at the greatest depths in the Derjugin Basin, Sea of Okhotsk.

Examination of the extensive original material of the bivalves of the Russian Pacific seas revealed a large species (shell length more than 60 mm) of the genus *Solemya* Lamarck, 1818, from the Sea of Okhotsk and the northern Sea of Japan. Species of this genus have not been previously listed in the fauna of Russia (Scarlato, 1981; Kantor & Sysoev, 2005). Attempts to identify this species showed that identification of solemyid species is generally difficult because of large similarity of the form, proportions, and external and internal morphology of the shell, as well as because of the lack of important diagnostic features of the bivalves, such as distinct shell sculpture, hinge teeth, and pallial sinus. Moreover, the original and subsequent descriptions of most of North Pacific *Solemya* species are very brief, either with no or few and insufficiently detailed figures and illustrations.

This also hinders identification of species and their comparative analysis. Among all species of the Solemyidae recorded in the North Pacific, *S. reidi* was studied in greatest detail. Morphology of the shell, anatomy, ecology, and metabolic peculiarities of this species and its intracellular symbiotic bacteria have been fairly well studied by several authors (Bernard, 1980; Reid, 1980; Felbeck, 1983, 1985; Powell & Somero, 1985, 1986; Anderson et al., 1987, 1990; Gustafson & Reid, 1988a, b; O'Brien & Vetter, 1990; Lee et al., 1992; Wilmot & Vetter, 1992; Cary, 1994; Valentich-Scott, 1998; Coan et al., 2000). However, Bernard (1980), in describing *S. reidi*, erroneously placed it in *Solemya s. str.* (Taylor et al., 2008), and the subsequent authors did not change its taxonomic position (Valentich-Scott, 1998; Coan et al., 2000). Unlike *S. reidi*, such North Pacific species as *P. pervernicosa, S. panamensis, P. pusilla*, and *S. valvulus* have been much less studied. The description of *P. pervernicosa* was given in Japanese, and it was illustrated with a photograph of the right valve of the holotype (Kuroda, 1948). Later, a few authors provided only very brief descriptions of this species, sometimes duplicating their earlier description and photograph (Kira, 1959; Okutani et al., 1988; Okutani, 2000). Dall (1908a) gave a description of *S. panamensis* without illustrations. Much later, only Bernard (1980) provided a schematic drawing of the hinge of this species. The original and few subsequent descriptions of *P. pusilla* and *S. valvulus* are very brief, often fragmentary, and insufficiently illustrated (Gould, 1861; Carpenter, 1864; Dall, 1908a; Habe, 1977; Bernard, 1980; Kuznetsov et al., 1990; Coan et al., 2000; Okutani, 2000). Moreover, comparative analysis of *Solemya* species from the Russia Pacific seas showed that there is a confusion in the systematics of the Solemyidae from the North Pacific. Taylor et al. (2008) noted an analogous situation in Australian representatives of the Solemyidae. Having examined in detail Australian solemyids and the type species of genera and subgenera of the Solemyidae, Taylor et al. (2008) pointed to mistakes in the diagnoses of some subgenera of *Solemya* and redefined the recognized world genera and subgenera of the Solemyidae on the basis of characters ligament and features of the posterior aperture.

Thus, the identification of *Solemya* species found in the Pacific seas of Russia necessitated a more thorough examination of other species of the Solemyidae from the northern Pacific Ocean, including the type species of the genera and subgenera of this family.

In this paper, I present the results of a comparative analysis of shell morphology and descriptions of some species of the genus *Solemya* from the North Pacific supplemented by new data on their shell morphology and geographical distribution. Also, I present additional data on the distribution and ecology of *A. johnsoni* obtained from the study of the material of *Acharax* sp. from the Derjugin Basin, Sea of Okhotsk, which was previously examined by Sahling et al. (2003), and additional material of this species from this region and other areas of the Pacific Ocean.

MATERIALS AND METHODS

Material Studied

The material of *Solemya* species from the Sea of Okhotsk on the southeastern coast of Sakhalin Island and the Sea of Japan near the western coast of Sakhalin Island was collected by the Japanese research and commercial expedition with Russian observer (SakhRIFO scientific program, June–August 1997, fishing-boat "Taihei-Maru-106", Sea of Okhotsk), and Russian research and commercial expedition (SakhRIFO scientific program, November–December 2003, fishing-boat "Vulkanny", Sea of Japan). The material of this species from the Sea of Okhotsk was fixed with 4% formaldehyde and stored in 70% ethanol at the MIMB. The material from the Sea of Japan (fragments of shells) is stored dry at the IMB.

The material of *A. johnsoni* from the Sea of Okhotsk was collected by the IO RAS expedition to the Sea of Okhotsk (August–October 1949, cruise 2 of R/V "Vityaz") and the international expedition to Sakhalin Island (July–August 1998, cruise 28 of R/V "Akademik M. A. Lavrentyev"); from the Eastern Pacific, by the IORAS expeditions (September–December 1968, cruise 4 of R/V "Akademik Kurchatov"; August–October 1990, cruise 22 of R/V "Akademik Mstislav Keldysh"). The material of this species was stored in 70% ethanol and dry at the IO RAS.

Also, collection material and photos of the following taxa were used: *A. johnsoni* (ZMU); *P. pervernicosa* (NSMT); *P. pusilla* (NSMT); *S. reidi* (RBCM, CS, EMD); *Solemya australis* Lamarck, 1818 (AMS); *Solemya parkinsonii* Smith, 1874 (NMNZ); *Solemya velesiana* Iredale, 1931 (AMS); *Solemya terraereginae* Iredale, 1929 (AMS); *Solemya* sp. (IO RAS); *Solemya togata* (Poli, 1795) (NMW, photos by P. G. Oliver); *Solemya borealis* Totten, 1834 (MCZ, photos by A. J. Baldinger); *S. valvulus* (SBMNH, photos by P. Valentich-Scott); *S. panamensis* (SBMNH, photos by P. Valentich-Scott).

Shell Measurements

Figure 1 shows the shell morphology measurements. Shell length (L), anterior end length (A), height (H) were measured. The ratios of these parameters to shell length (A/L, H/L, respectively) were determined. Shell measurements were made using a caliper and an ocular micrometer with an accuracy of 0.1 mm.

Abbreviations

The following institutional abbreviations are used in the paper: AMS – Australian Museum, Sydney; CS – Columbia Science, Royston; BMNH – Natural History Museum, London; EMD – Environmental Monitoring Division, Los Angeles; IMB – A. V. Zhirmunsky Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok; IO RAS – P. P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow; MCZ – Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; MIMB – Museum of the Institute of Marine Biology, Vladivostok; NMNZ – Museum of New Zealand Te Papa Tongarewa, Wellington; NMW – National Museums & Galleries of Wales, Cardiff; NSMT – National Science Museum, Tokyo; RBCM – Royal British Columbia Museum, Victoria; SakhRIFO – Sakhalin Scientific Research Institute of Fisheries & Oceanography, Yuzno-Sakhalinsk; SBMNH – Santa Barbara Museum of Natural History, Santa Barbara, California; USNM – United States National Museum of Natural History, Smithsonian Institute, Washington, D.C.; ZMMU – Zoological Museum of Moscow University, Moscow; ZMU – Zoological Museum of Far East State University, Vladivostok.

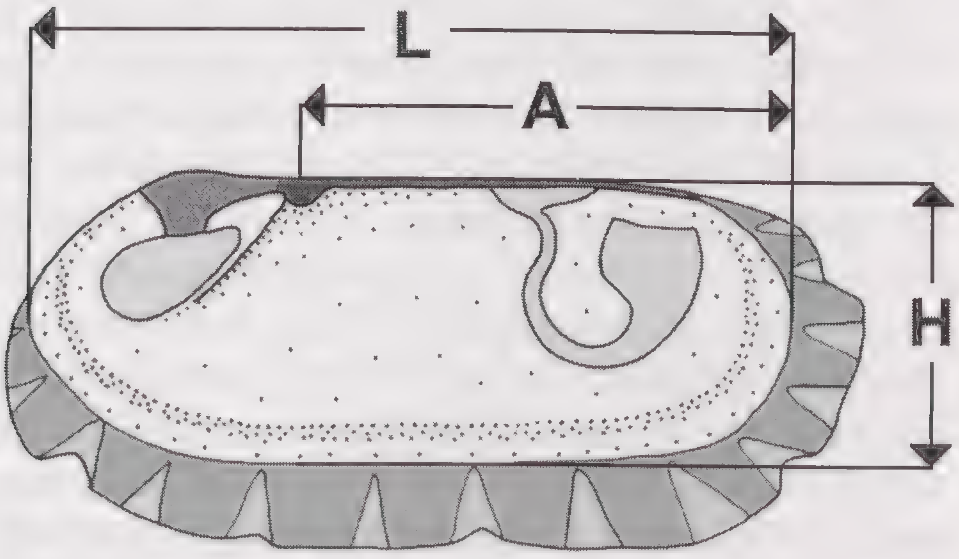


FIG. 1. Placement of shell measurements: L – shell length; H – height; A – anterior end length.

SYSTEMATICS

Family Solemyidae Gray, 1840
Genus *Solemya* Lamarck, 1818

Type Species – *Solemya mediterranea* Lamarck, 1818, = *Tellina togata* Poli, 1795; subsequent designation by Children, 1823.

Diagnosis

Shell thin, flexible, poorly mineralized, elongate-oval, inflated to compressed, inequilateral, equivalve. Beaks obscure, not prominent, near posterior end. Periostracum adherent, varnished, extending beyond shell. Surface with widely spaced weak radial ribs or furrows. Lunule and escutcheon absent. Ligament opisthodetic, internal, attached to chondrophore, sometimes with a lateral expansion in front of chondrophore. Chondrophore oblique, sometimes supported by a radial rib. Hinge plate weak, edentate. Adductor scars unequal; posterior scar small and impressed; anterior scar large, continuous with a pedal retractor scar.

The genus contains 16 living species.

Remarks

The genus *Solemya* was introduced with merely two species, *S. australis* and *S. mediterranea* (Dall, 1908a; Iredale, 1931; Bernard., 1980). The first listed, *S. australis*, was given as an example by Bowdich (1822), and this was incorrectly taken as a designation of a type species, such as by Dall (1908a). Children (1823) designated *S. mediterranea* as type. Nevertheless, a number of authors have accepted *S. australis* as the type species of *Solemya* (Dall, 1908a; Cox, 1969). Vokes (1955) showed that the first valid designation was *S. mediterranea* (= *T. togata*).

Dall (1908a) proposed subgeneric differentiation of *Solemya* species based on the type and structure of the ligament. He divided *Solemya* into three subgenera *Solemya* s.s., *Petrasma* Dall, 1908, and *Acharax* Dall, 1908. In Dall's (1908a) classification, the subgenus *Solemya* s.s. has an internal ligament with a lateral expansion in front of the chondrophore; the subgenus *Petrasma* also has an internal ligament, but without a lateral expansion in front of the chondrophore, and the subgenus *Acharax* has an external ligament. However, Dall (1908a) considered the type species of the genus *Solemya* to be *S. australis*, not

Solemya togata (Poli, 1795). Therefore, Dall's (1908a) diagnosis of *Solemya* s.s. was primarily made on the basis of the ligament structure of *S. australis*. Dall (1908a) included *S. togata* in the subgenus *Solemya* s.s. and indicated that in this species "… the anterior exposure of the internal part of the ligament is reduced to a narrow line directed backward to the upper anterior angle of the posterior adductor scar." In reality, unlike *S. australis*, *S. togata* lacks a lateral expansion of the internal ligament in front of the chondrophore (Taylor et al., 2008) and has instead only narrow strips of internal ligament under the chondrophore (Fig. 2). Since *S. togata* is the type species of the genus *Solemya*, the diagnosis of the subgenus *Solemya* s.s. should be modified according to features of the shell morphology of *S. togata*. However, some workers (Bernard, 1980; Coan et al., 2000), subsequently indicated *S. togata* to be the type species of the genus *Solemya* but retained Dall's (1908a) diagnosis of *Solemya* s.s.

Based on ligament structure and external shell morphology, Iredale (1931) introduced the genus *Solemyarina* Iredale, 1931, to accommodate two small Australian species, *S. velesiana*, and *S. terraereginae*, and designated *S. velesiana* as its type species. Later, Iredale (1938) included in the genus *Solemyarina* a subgenus *Zesolemya* Iredale, 1938, with *S. parkinsonii*, from New Zealand as its type species.

Cox (1969) placed *Zesolemya* in synonymy of *Solemyarina*, which he recognized as a subgenus of *Solemya*. He gave an accurate diagnosis of the subgenus *Solemya* s.s., describing the ligament and chondrophore of the type species *S. togata*. Also, Cox (1969) noted that *S. australis*, which some authorities have accepted as type species of *Solemya*, belongs to the subgenus *Solemyarina*. However, Lamprell & Healy (1998) returned *S. australis* to *Solemya* s.s.

Bernard (1980), probably adhering to Dall's (1908a) diagnosis of *Solemya* s.s., noted that *Solemya* s.s. has a lateral expansion of the internal ligament in front of the chondrophore. Relying on this diagnosis, he thought that the genus *Solemyarina* and the subgenus *Zesolemya* recognized by Iredale (1931, 1938) fell into *Solemya* s.s. and the genus *Solemya* contained only two living subgenera, *Solemya* s.s. and *Petrasma*. Japanese malacologists came to consider these to be full genera of the Solemyidae (Habe, 1977, 1981; Okutani et al., 1988; Tsuchida & Kurozumi, 1993; Higo et al., 1999; Okutani, 2000).

Coan et al. (2000) believed that the genus *Solemya* in the North Pacific comprised the subgenera *Solemya* s.s. and *Petrasma*, but their diagnoses of these subgenera repeated those of Bernard (1980). Their subgeneric differentiation was based not only on the morphology of the ligament, but also on the presence or absence of an internal rib supporting the chondrophore. In the opinion of Coan et al. (2000), the main character distinguishing *Solemya* s.s. is the presence of an internal, subumbonal expansion or lateral lobes of the ligament in front of the chondrophore and a radial rib supporting the chondrophore, with the species of the subgenus *Petrasma* having no internal lobes of the ligament in front of the chondrophore and nor a radial rib supporting the chondrophore. However, in reality, *S. togata* (type species of *Solemya* s.s.) has no internal lobes of the ligament in front of the chondrophore and nor a radial rib supporting the chondrophore, whereas *S. borealis* (type species of subgenus *Petrasma*) has a radial strengthening rib of chondrophore (Figs. 2, 3). In a recent work, Japanese malacologists (Okutani et al., 2003) have also begun to follow generic/subgeneric differentiation of the Solemyidae proposed by Bernard (1980) and Coan et al. (2000).

Taylor et al. (2008) thoroughly studied Australian solemyids and types of all previously recognized genera and subgenera of the Solemyidae. They revealed all main inaccuracies in the systematics of the Solemyidae made by previous authors. Based on ligament characters and features of the posterior aperture, they recognized the subgenera within the genus *Solemya* – *Petrasma* (type species *S. borealis*), *Solemyarina* Iredale, 1931 (type species *S. velesiana*) and *Zesolemya* Iredale, 1938 (type species *S. parkinsonii*), and additionally proposed a new subgenus *Austrosolemya* Taylor, Glover & Williams, 2008, with *S. australis* as its type species (Figs. 3–6). Taylor et al. (2008) described, in detail, the ligament, chondrophore and associated structures, and posterior aperture of all type species of the genera and subgenera of the Solemyidae. These features of type species provided the basis for generic and subgeneric differentiation of the Solemyidae. The characters of posterior aperture such as the number and arrangement of papillae were suggested as having some potential in the solemyid systematics. Thus, many previous authors (Dall, 1908a; Cox, 1969; Bernard, 1980; Coan et al., 2000), as a rule, split the genus *Solemya* into subgenera primarily on the basis of two characters, namely, the presence or absence of an expansion of the internal ligament in front of the chondrophore and ridges supporting the chondrophore. Taylor et al. (2008) included in the diagnosis of subgenera a complex of characters, including the form of the internal ligament, form of the expansion of the internal ligament in front of the chondrophore, form of the chondrophore, and form of the inner ribs strengthening the chondrophore.

The study of all Pacific species of *Solemya* and the type species of genera and subgenera of living Solemyidae shows that, in my opinion, all Pacific species of the genus *Solemya* recorded along the coasts of Asia and America may be referred to the subgenera *Solemya* s.s. and *Petrasma*. Also, as a result of detailed examination of the type species of solemyid genera and subgenera and the emendation of the diagnoses of *Solemya* s.s. and *Petrasma*, the taxonomic position of some Pacific species is herein changed.

Subgenus *Solemya* s.s.

Diagnosis

Internal ligament broad, subtriangular, sometimes with posterior extensions. Lateral expansion of ligament in front of chondrophore absent. Chondrophore not supported by a radial rib, not bounding anterodorsal margin of posterior adductor scar. Anterior end of posterior adductor scar not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore.

Remarks

The subgenus *Solemya* s.s. primarily differs from the subgenera *Solemyarina*, *Zesolemya*, and *Austrosolemya* in lacking a lateral expansion of internal ligament in front of the chondrophore (Figs. 2–6, Table 1). Although similar to many species of the subgenus *Petrasma* in having no lateral expansion of the internal ligament in front of the chondrophore, the subgenus *Solemya* s.s. differs from it in that the chondrophore is not supported by a radial rib bounding the anterior margin of the posterior adductor scar, and the anterior end of the posterior adductor scar is not impressed into the inner shell surface and does not adjoin the anteroventral margin of the chondrophore.

Solemya (*Solemya*) *pusilla* Gould, 1861
(Figs. 7–14)

Solemya pusilla Gould, 1861: 27.
Solemya (*Petrasma*) *pusila* Gould – Dall, 1908a: 364.
Petrasma pusilla (Gould, 1861) – Habe, 1977: 11, pl. 1, figs. 3, 4; Habe, 1981: 25; Tsuchida & Kurozumi, 1993: 2–3, pl. 1, fig. 1; Higo et al., 1999: 413; Okutani, 2000: 833, pl. 414, fig. 3.
Solemya (*Solemya*) *pusilla* Gould, 1861 – Bernard et al., 1993: 20.

Type Material and Locality

Holotype (USNM 24204), Hakodadi Bay (Hakodate, Hokkaido, Japan), 9.1 m, muddy bottom (Higo et al., 1999; P. Valentich-Scott, personal communication).

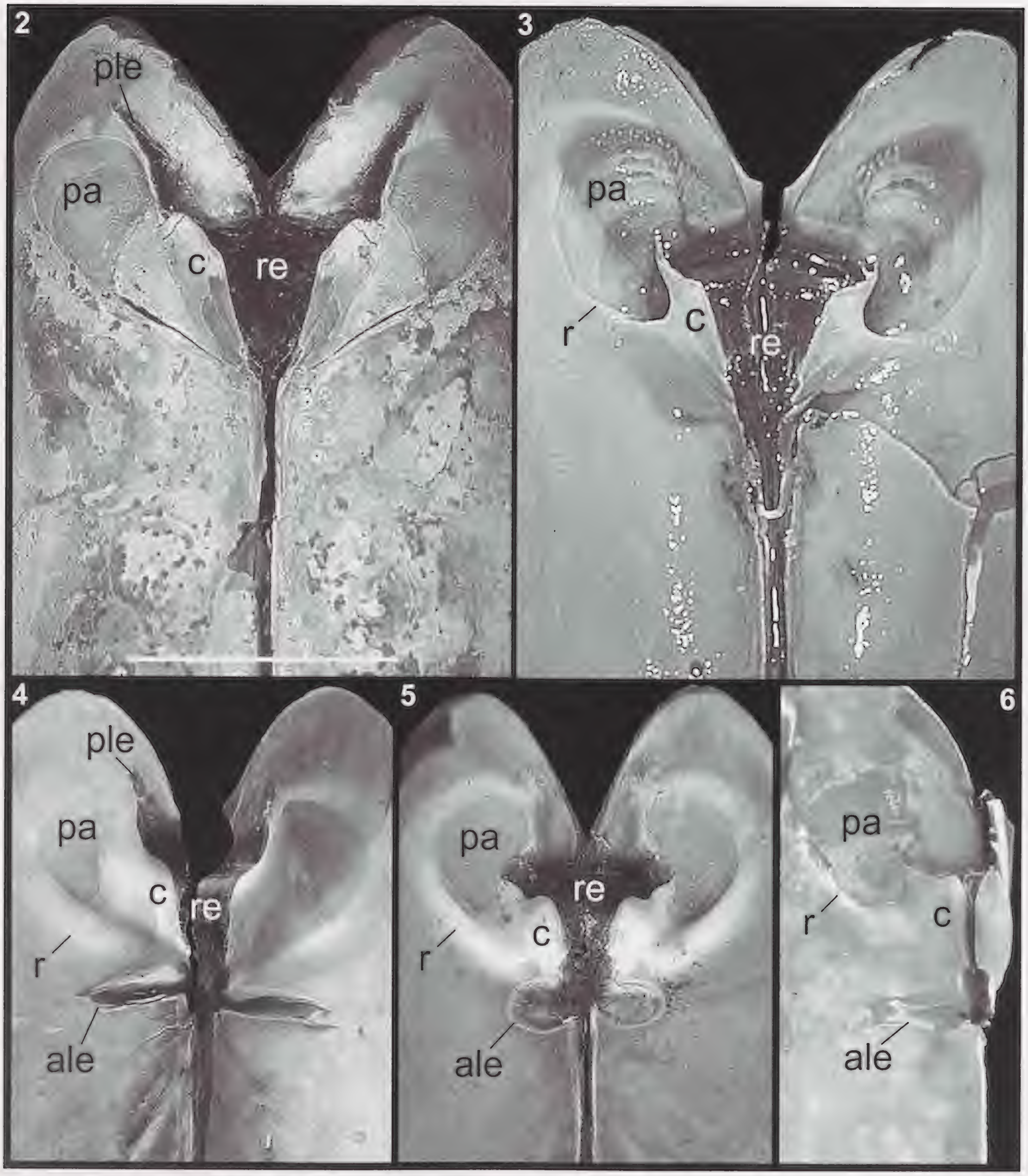
Material Examined

Four specimens (NSMT Mo 48815) and 3 specimens (NSMT Mo 76805), Loc. Tomioka, Amakusa Islands, Kyushu, Japan; 4 specimens (NSMT Mo 60259), Loc. Tsukumo Bay, Ishikawa Prefecture, Honshu, Japan. Total of 11 specimens.

Description

Exterior: Shell small (to 15 mm), elongate-oval, equivalve, strongly inequilateral, thin, flexible, poorly mineralized, semitransparent. Sculpture of very low, broad, widely spaced radial ribs in anterior part of shell and weak, fine ribs in central and posterior parts of shell. Periostracum thin, grayish-yellow, almost white in umbonal area, widely extending beyond shell margin. Beaks very small, obscure, not prominent, near posterior end. Anterior shell end gently rounded. Posterior shell end slightly angular, with a noticeable, short, radial, oblique flexure, corresponding to attachment of chondrophore to inner shell surface. Posterodorsal shell margin slightly convex in internal ligament area, forming a small, smooth, obtuse angle, smoothly transitioning to slightly angular posterior margin. Anterodorsal shell margin straight, parallel to ventral margin, smoothly transitioning to rounded anterior margin. Ventral margin straight.

Interior: Ligament thin, subtriangular, moderately broad, with short sharpened posterior extensions, attached to chondrophore, lacking



FIGS. 2–6. Ventral view of ligament and chondrophore of type species of subgenera of the genus *Solemya*. FIG. 2: *Solemya togata* (type species of *Solemya* s.s.), Mediterranean Sea (NMW, photo by P. G. Oliver); FIG. 3: *Solemya borealis* (type species of *Petrasma*), Cape Cod Bay, 5 mi. N of Barnstable MA., Atlantic Ocean, shell length 57.0 mm, (MCZ 302391, photo by A. J. Baldinger); FIG. 4: *Solemya parkinsonii* (type species of *Zesolemya*), N Douglas, Auckland, Tamaki Strait, Kawaka Bay, North Island, New Zealand, shell length 35.5 mm, (NMNZ M 274993); FIG. 5: *Solemya australis* (type species of *Austrosolemya*), 35°15.000'S, 137°0.000'E, South Australia, shell length 45.0 mm, (AMS C 085088); FIG. 6: *Solemya velesiana* (type species of *Solemyarina*), Port Jackson, Sydney (BMNH-95.3.7.17-19) (from Taylor et al., 2008, fig. 1C). ale, anterior lateral expansion; c, chondrophore; pa, posterior adductor scar; ple, posterior lateral extension; r, radial rib in front of posterior adductor scar; re, resilium. Scale bar = 5 mm.

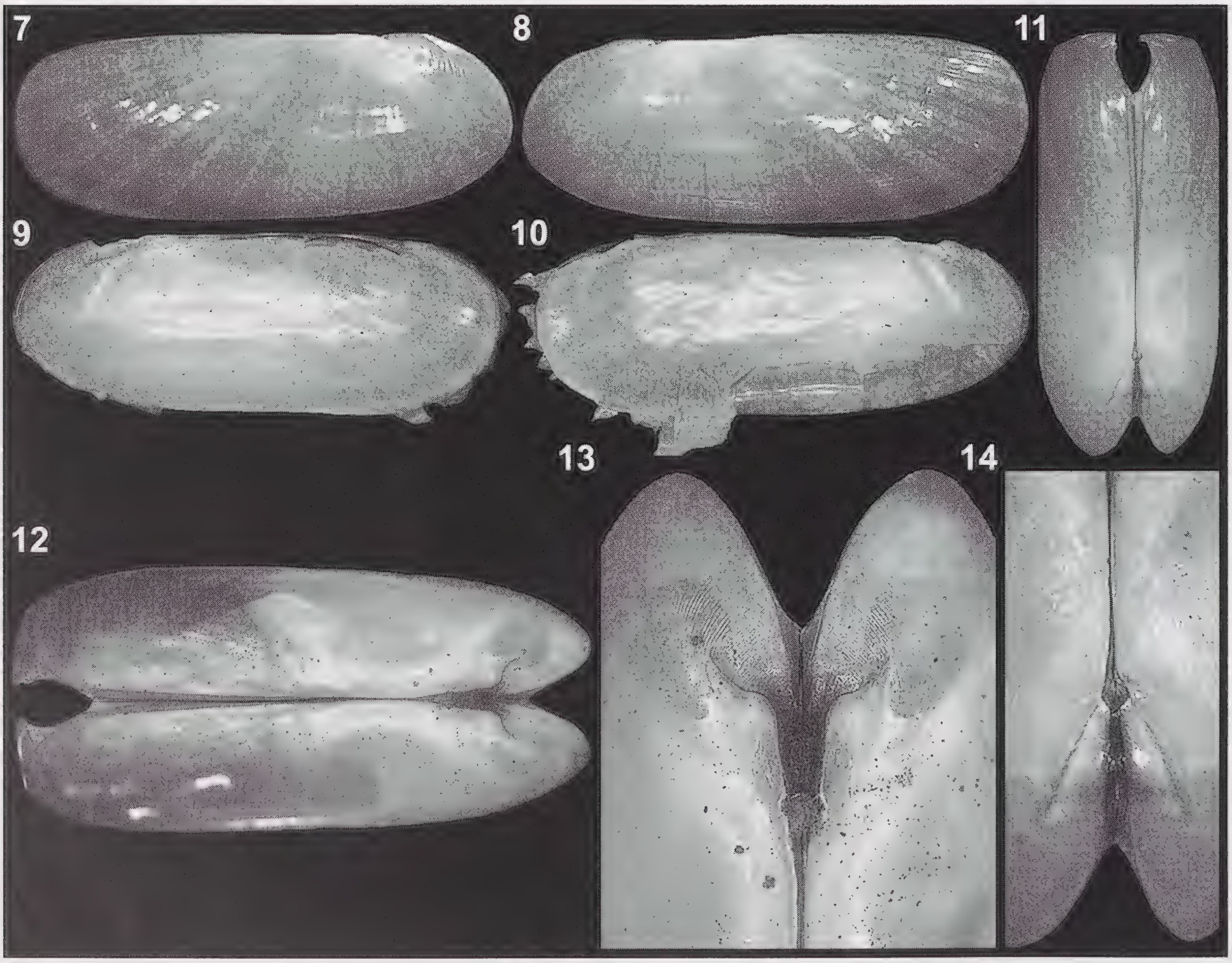
TABLE 1. Comparison of main morphological characters among subgenera of the genus *Solemya*.

Characters	*Austrosolemya*	*Petrasma*	*Solemya* s.s.	*Solemyarina*	*Zesolemya*
Resilium	Subtriangular, broad	Subtriangular, broad	Subtriangular, broad	Narrow	Subtriangular, broad, with narrow posterior extensions
Internal ligament expansion in front of chondrophore	Two large, oval, lateral lobes	Absent or small, irregular, sometimes elongate along shell dorsal margin	Absent	Heart-shaped, with two narrow, short, lateral striae	Two narrow, long, lateral striae
Internal radial rib in front of posterior adductor scar	Strong, broad, high, supporting anterior end of chondrophore	Week, narrow, low, supporting posterior end of chondrophore	Absent	Week, narrow, low, not supporting chondrophore	Weak, broad, low, not supporting chondrophore
Chondrophore	Short, thick, not bounding anterodorsal margin of posterior adductor scar	Short, thick, bounding anterodorsal margin of posterior adductor scar	Short, thin, not bounding anterodorsal margin of posterior adductor scar	Short, thin, not bounding anterodorsal margin of posterior adductor scar	Long, thin, not bounding anterodorsal margin of posterior adductor scar
Posterior adductor scar	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore	Impressed into inner shell surface, adjoining anteroventral margin of chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore

an expansion in front of chondrophore, visible externally as sunken, small, brown, diamond-shaped button behind beaks. Chondrophore strong, long, thin, oblique, situated above posterior adductor scar, not bounding anterodorsal margin of posterior adductor scar. Internal radial rib in front of posterior adductor scar very weak, low, broad, not supporting chondrophore. Anterior adductor scar large, angular-oval, well impressed. Posterior scar smaller, ovate-triangular, well impressed, not adjoining anteroventral margin of chondrophore, extending behind chondrophore. Shell interior grayish, with weak, dense radial lines. Digestive tract present.

Comparisons

This species is easily distinguished from the Pacific species *S. australis, S. parkinsonii, S. pervernicosa, S. terraereginae,* and *S. velesiana* by the lack of an internal expansion of the ligament in front of the chondrophore (Table 2). In contrast to *S. panamensis* (Figs. 22–30), *S. pusilla* has sharpened posterior extensions of the resilium, the posterior adductor scar does not adjoin the anteroventral margin of the chondrophore, and the internal radial rib in front of the anterior margin of the posterior adductor scar does not support the chondrophore. *Solemya pusilla* is closest to *S. tagiri, S. valvulus,* and *Solemya moretonensis* Taylor, Glover & Williams, 2008. *Solemya pusilla* differs from *S. tagiri* in having an internal radial rib in front of the anterior margin of the posterior adductor scar, sharpened posterior extensions of the resilium, a longer chondrophore, and alimentary canal; from *S. valvulus* (Figs. 15–21), in having a radial rib in front of the anterior margin of the posterior adductor scar and that the posterior



FIGS. 7–14. *Solemya (Solemya) pusilla*, Loc. Tomioka, Amakusa Islands, Kyushu, Japan (NSMT-Mo 76805). FIGS. 7–10: Exterior and interior views of left and right valves, shell length 7.3 mm; FIGS. 11–14: Dorsal and interior views of both valves, ventral view of ligament and chondrophore, dorsal view of umbonal area, shell length 10.0 mm.

adductor scar extends behind the chondrophore. Unlike *S. moretonensis*, the posterior adductor scar of *S. pusilla* extends behind the chondrophore.

Distribution and Habitat

Solemya (*Solemya*) *pusilla* occurs in the western Pacific off Japan from the Kii Peninsula (Honshu, Pacific Ocean) and Seto Inland Sea to southern Hokkaido; in the Sea of Japan (Tsukumo Bay, Ishikawa Prefecture, Japan – NSMT Mo 60259); in the East China Sea (Amakusa Island, Kyushu, Japan – NSMT Mo 48815, 76805); in the Yellow Sea. This species has been recorded from the intertidal zone to 20 m, on sandy silt, silt with a smell of hydrogen sulphide (Habe, 1977, 1981; Kuznetsov et al., 1990; Bernard et al., 1993; Tsuchida & Kurozumi, 1993; Higo et al., 1999; Okutani, 2000).

Solemya (*Solemya*) *valvulus* Carpenter, 1864
(Figs. 15–21)

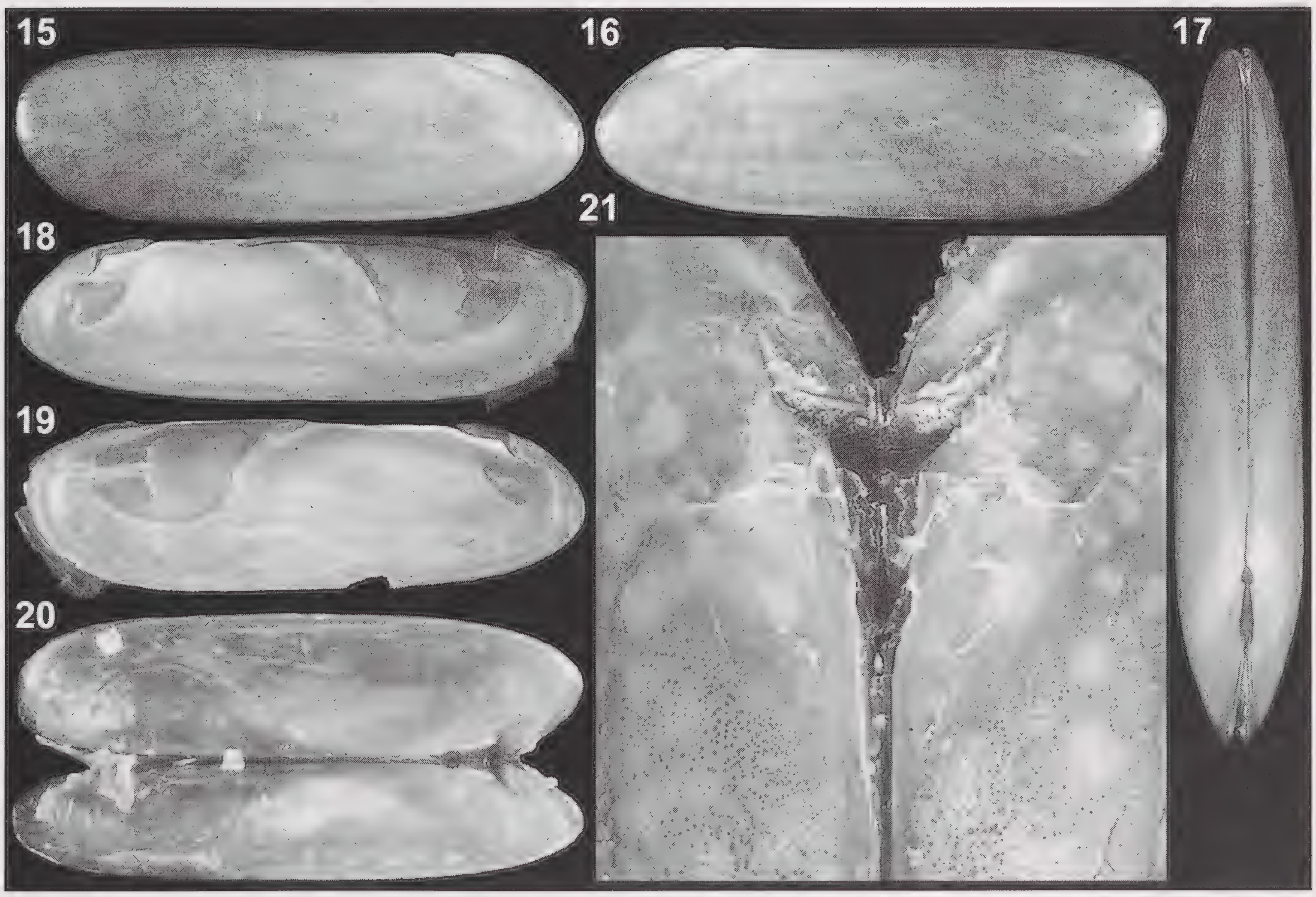
Solenomya valvulus Carpenter, 1864: 311.
Solemya (*Petrasma*) *valvulus* Carpenter – Dall, 1908a: 364.
Solemya (*Petrasma*) *valvulus* Carpenter, 1864 – Bernard, 1980: 18, fig. 3; Bernard, 1983: 9.
Solemya (*Petrasma*) *valvulus* (Carpenter, 1864) – Coan et al., 2000: 66, pl. 1.

Type Material and Locality

Type is lost. Cabo San Lucas, Baja California Sur, Mexico (Palmer, 1958; E. V. Coan & P. Valentich-Scott, personal communication)

Description

Exterior: Shell small (to 20 mm), elongate-oval, equivalve, strongly inequilateral, thin, flexible, poorly mineralized. Sculpture of very low, broad, widely spaced radial ribs, less expressed medially, and narrow, radial, thread-like ribs in space between broad ribs of anterior shell end.



FIGS. 15–21. *Solemya (Solemya) valvulus*, Bahia Santiago (19°06'24"N, 104°22'28"W), Colima, Mexico, Pacific Ocean (SBMNH 83479, photos by P. Valentich-Scott). FIGS. 15–17: Exterior view of left and right valves, dorsal view of both valves, shell length 17.75 mm; FIGS. 18, 19: Interior view of left and right valves, shell length 16.25 mm; FIGS. 20, 21: Interior views of both valves, ventral view of ligament and chondrophore, shell length 17.08 mm.

TABLE 2. Main differentiating characters of *Solemya* species from the Pacific Ocean.

Species	Maximum shell length, mm	Resilium	Internal ligament expansion in front of chondrophore	Chondrophore	Internal radial rib in front of posterior adductor scar	Posterior adductor scar	Alimentary system	References
Solemya (Solemya) pusilla	14.5	Subtriangular, broad, with very short, sharpened posterior extensions	Absent	Long, thin, not bounding anterodorsal margin of posterior adductor scar	Very weak, broad, low, not supporting chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore, extending behind chondrophore	Present	Dall, 1908; Habe, 1977; Kuznetsov et al., 1990; Okutani, 2000
Solemya (Solemya) valvulus	20.0	Subtriangular, broad, with sharpened posterior extensions	Absent	Long, thin, not bounding anterodorsal margin of posterior adductor scar	Absent	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore, not extending behind chondrophore	Present	Dall, 1908; Coan et al., 2000
Solemya (Solemya) tagiri	23.8	Subtriangular, broad	Absent	Very short, thin, not bounding anterodorsal margin of posterior adductor scar	Absent	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore, not extending behind chondrophore	Absent	Okutani et al., 2003
Solemya (Petrasma) panamensis	47.0	Subtriangular, broad	Absent	Short, thin, bounding anterodorsal margin of posterior adductor scar	Week, narrow, low, supporting anterior end of chondrophore	Impressed into inner shell surface, adjoining anteroventral margin of chondrophore, extending behind chondrophore	Present	Dall, 1908; Coan et al., 2000
Solemya (Petrasma) pervernicosa	63.1	Subtriangular, broad	Oval or elongate-oval, often irregularly shaped, with short lateral rays	Short, thick, bounding anterodorsal margin of posterior adductor scar	Week, narrow, low, supporting posterior end of chondrophore	Impressed into inner shell surface, adjoining anteroventral margin of chondrophore, extending behind chondrophore	Absent	Kuroda, 1948; Bernard, 1980; Okutani et al., 1988; Valentich-Scott, 1998; Coan et al., 2000; Okutani, 2000

(continues)

(continued)

Species	Maximum shell length, mm	Resilium	Internal ligament expansion in front of chondrophore	Chondrophore	Internal radial rib in front of posterior adductor scar	Posterior adductor scar	Alimentary system	References
Solemya (Solemyarina) terraereginae	8.0	Narrow, with parallel dorsal edges of chondrophore	Heart-shaped, with two narrow, short, lateral striae	Short, thin, not bounding anterodorsal margin of posterior adductor scar	Week, narrow, low, supporting anterior end of chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore, extending behind chondrophore	Present	Iredale, 1929, 1938; Taylor et al., 2008
Solemya (Solemyarina) velesiana	16.0	Narrow, with parallel dorsal edges of chondrophore	Heart-shaped, with two narrow, short, lateral striae	Short, thin, not bounding anterodorsal margin of posterior adductor scar	Week, narrow, low, not supporting chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore, extending behind chondrophore	Present	Iredale, 1931; Lamprell & Healy, 1998; Taylor et al., 2008
Solemya (Zesolemya) parkinsonii	75.0	Subtriangular, broad, with long, rounded posterior extensions	Two narrow, long, lateral striae	Very long, thin, not bounding anterodorsal margin of posterior adductor scar	Weak, broad, low, not supporting chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore, not extending behind chondrophore	Present	Smith, 1874; Dall, 1908; Owen, 1961; Beedham & Owen, 1965; Taylor et al., 2008
Solemya (Austrosolemya) australis	60.0	Subtriangular, broad	Two large, oval, lateral lobes	Short, thick, not bounding anterodorsal margin of posterior adductor scar	Strong, broad, high, supporting anterior end of chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore, extending behind chondrophore	No data	Dall, 1908; Cox, 1969; Lamprell & Healy, 1998; Taylor et al., 2008
Solemya (s.l.) *moretonensis*	6.6	Subtriangular, broad, with short, sharpened posterior extensions	Absent	Long, thin, not bounding anterodorsal margin of posterior adductor scar	Very weak, narrow, low, not supporting chondrophore	Not impressed into inner shell surface, not adjoining anteroventral margin of chondrophore, not extending behind chondrophore	No data	Taylor et al., 2008

Periostracum thick, brown at anterior shell end and light brown or yellow at posterior shell end and umbonal area, widely extending beyond shell margin. Beaks very small, obscure, not prominent, near posterior end. Anterior shell end gently rounded. Posterior shell end slightly angular and narrowed, with a well expressed radial, oblique flexure, corresponding to attachment of chondrophore to inner shell surface. Posterodorsal shell margin slightly convex in internal ligament area, forming a small smooth, obtuse, angle, smoothly transitioning to slightly angular posterior margin. Anterodorsal shell margin straight, parallel to ventral margin, smoothly transitioning to rounded anterior margin. Ventral margin straight.

Interior: Ligament thin, subtriangular, moderately broad, with sharpened posterior extensions, attached to chondrophore, without an expansion in front of chondrophore, visible externally as sunken, small, brown, subtriangular button behind beaks. Chondrophore strong, long, oblique, situated above posterior adductor scar, not bounding anterodorsal margin of posterior adductor scar. Internal radial rib in front of posterior adductor scar absent. Anterior adductor scar large, angular-oval, feebly impressed. Posterior scar smaller, ovate-triangular, well impressed, not adjoining anteroventral margin of chondrophore, not extending behind chondrophore. Shell interior dull, with weak radial lines more conspicuous along ventral shell margin. Digestive tract present.

Comparisons

This species is readily distinguished from the Pacific species *S. australis, S. parkinsonii, S. pervernicosa, S. terraereginae,* and *S. velesiana* by the lack of an internal expansion of the ligament in front of the chondrophore and a radial rib bounding the anterior margin of the posterior adductor scar (Table 2). Also, *S. valvulus* is easily distinguished from *S. panamensis* (Figs. 22–30) by the lack the radial rib bounding the anterior margin of the posterior adductor scar, in having sharpened posterior extensions of the resilium and the ovate-triangular posterior adductor scar not adjoining the anteroventral margin of the chondrophore and not extending behind the chondrophore. *Solemya valvulus* is most similar to *S. pusilla, S. tagiri,* and *S. moretonensis. Solemya valvulus* differs from *S. tagiri* in having sharpened posterior extensions of the resilium, a longer chondrophore, and alimentary canal; from *S. moretonensis* and *S. pusilla* by the lack the radial rib in front of the anterior margin of the posterior adductor scar. Moreover, as compared with *S. pusilla* (Figs. 15–21), the posterior adductor scar of *S. valvulus* does not extend behind the chondrophore.

Distribution and Habitat

Solemya (*Solemya*) *valvulus* occurs from Bahía Santiago, Colima, Mexico (19°06’24”N, 104°22’28”W) (SBMNH 83479) to Monterey, California (36.7°N), including the Gulf of California. The species has been recorded from the intertidal zone to 360 m, in fine sediments (Coan et al., 2000; P. Valentich-Scott, personal communication).

Solemya (*Solemya*) *tagiri*
Okutani, Hashimoto & Miura, 2003

Solemya (*Solemya*) *tagiri* Okutani, Hashimoto & Miura, 2003: 91–96, figs. 2–5.

Type Material and Locality

Holotype (NSMT-Mo 73543) and paratypes (NSMT-Mo 73544; Japan Marina Science & Technology Center 031576-031578, 031588-031594, 053181-053191), Kagoshima Bay (31°39.55–58’N, 130°48.14–20’E), 94–98 m (Okutani et al., 2003).

Diagnosis

Shell small (to 24 mm), elongate-oval, equivalve, strongly inequilateral. Posterior and anterior shell ends gently rounded. Sculpture of weak, fine ribs and furrows, more expressed at anterior and posterior shell ends. Periostracum thin, yellowish-brown. Beaks small, not prominent. Ligament internal, thin, subtriangular, attached to chondrophore, visible externally as sunken diamond-shaped button behind beaks, without an expansion in front of chondrophore. Chondrophore weak, very short, thin, situated in front of posterior adductor scar. Internal radial rib in front of posterior adductor scar absent. Anterior adductor scar ovate-quadrate. Posterior adductor scar rounded, extending behind chondrophore. Digestive tract absent.

Comparisons

Solemya tagiri is distinguished from *S. australis, S. parkinsonii, S. pervernicosa, S. terraereginae,* and *S. velesiana* by the lack of an internal expansion of the ligament in front of the chondrophore and a radial rib bounding the anterior margin of the posterior adductor scar (Table 2). *Solemya tagiri* differs from *S. panamensis* by the lack the radial rib bounding the anterior margin of the posterior adductor scar and in having a very short chondrophore. *Solemya tagiri* is most similar to *S. pusilla, S. valvulus,* and *S. moretonensis*; but differs in having a very short chondrophore and the lack of sharpened posterior extensions of the resilium and alimentary canal. Moreover, in contrast to *S. pusilla* and *S. moretonensis*, *S. tagiri* has no radial rib in front of the anterior margin of the posterior adductor scar.

Distribution and Habitat

Solemya (*Solemya*) *tagiri* occurs in Kagoshima Bay (southern Kyushu, Japan). This species has been recorded at depths from 76 to 116 m in the area of submarine fumaroles (Okutani et al., 2003).

Subgenus *Petrasma* Dall, 1908

Type species – *Solemya borealis* Totten, 1834, by original designation.

Diagnosis

Internal ligament broad, subtriangular, sometimes with a small, irregularly shaped lateral expansion in front of chondrophore. Chondrophore bounding anterodorsal margin of posterior adductor scar, supported by a radial rib. Anterior end of posterior adductor scar impressed into inner shell surface, adjoining anteroventral margin of chondrophore.

Remarks

The subgenus *Petrasma* differs from all subgenera of the genus *Solemya* in that the ventral margin of the chondrophore bounds the anterodorsal margin of the posterior adductor scar and the anterior end of the posterior adductor scar is impressed into the inner shell surface (Figs. 2–6, Table 1). Also, this subgenus is distinguished from almost all subgenera, except the subgenus *Austrosolemya*, by the presence of a radial rib supporting the chondrophore in front of the posterior adductor scar. The subgenus *Petrasma* further differs from the subgenera *Solemyarina*, *Zesolemya*, and *Austrosolemya* either in the lack or in shape of the lateral expansion of internal ligament in front of the chondrophore.

Solemya (*Petrasma*) *panamensis* Dall, 1908
(Figs. 22–32)

Solemya (*Petrasma*) *panamensis* Dall, 1908a: 366; Bernard, 1980: 18, fig. 2; Bernard, 1983: 9.

Type Material and Locality

Holotype (USNM 110678), Panama Bay (8°44'N, 79°09'W), 54 m, “Albatross” station 2799, collected 6 March 1888 (Dall, 1908a; Bernard, 1980; P. Valentich-Scott, personal communication).

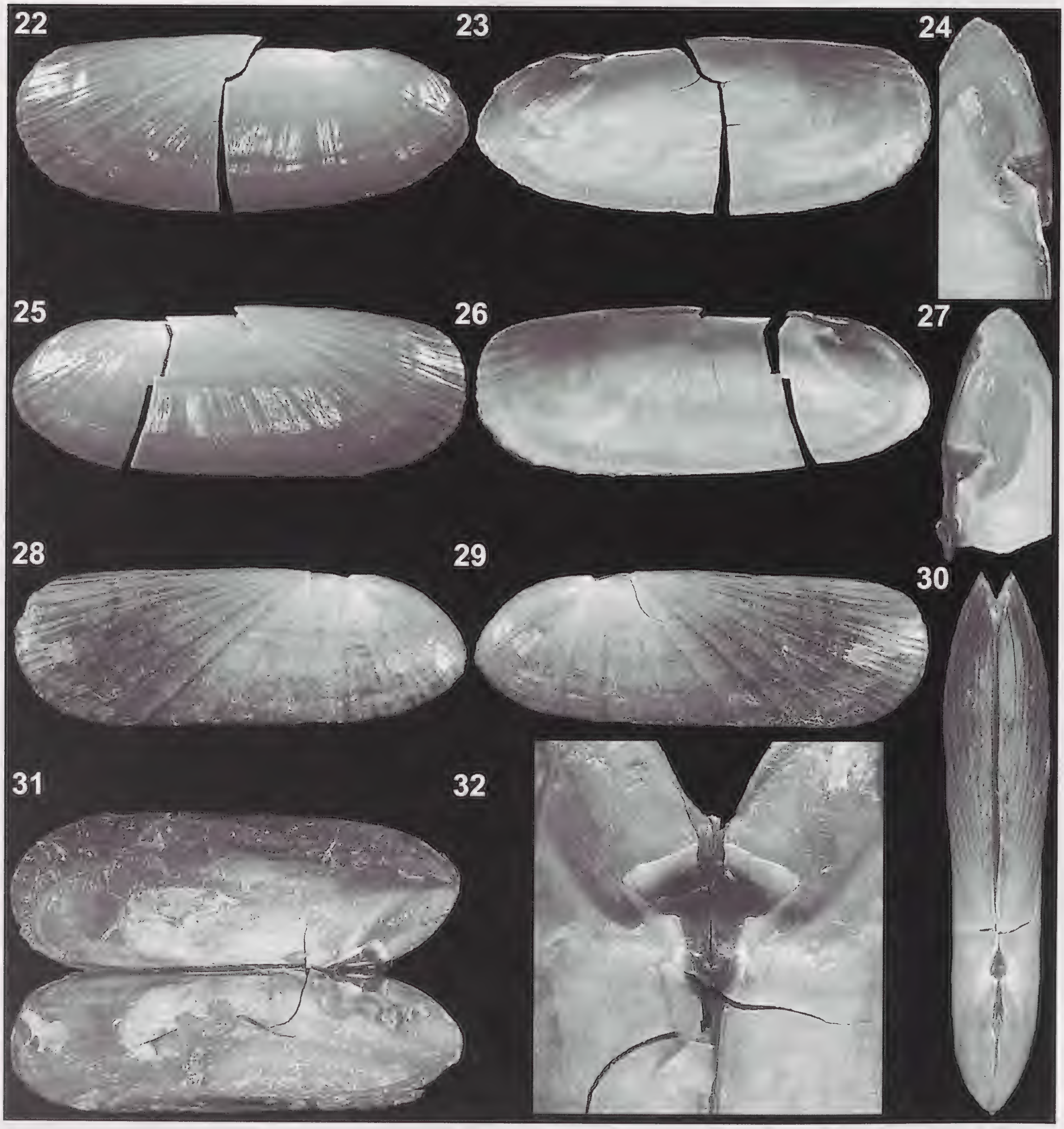
Description (expanded from Dall, 1908a)

Exterior: Shell large (to 47 mm), elongate-oval, equivalve, strongly inequilateral, thin, flexible, poorly mineralized. Sculpture of very low, broad, widely spaced radial ribs, less expressed medially and narrow, radial, thread-like ribs in space between broad ribs of anterior shell end. Periostracum thick, brown at anterior and posterior shell ends and yellowish-brown or yellow in umbonal area, widely extending beyond shell margin. Beaks very small, obscure, not prominent, near posterior end. Anterior shell end gently rounded. Posterior shell end slightly angular, pointed, with a slightly noticeable, short, radial, oblique flexure, corresponding to attachment of chondrophore to inner shell surface. Posterodorsal shell margin slightly convex in internal ligament area, forming a small, smooth, obtuse angle, smoothly transitioning to slightly pointed posterior margin. Anterodorsal shell margin straight, parallel to ventral margin, smoothly transitioning to rounded anterior margin. Ventral margin straight.

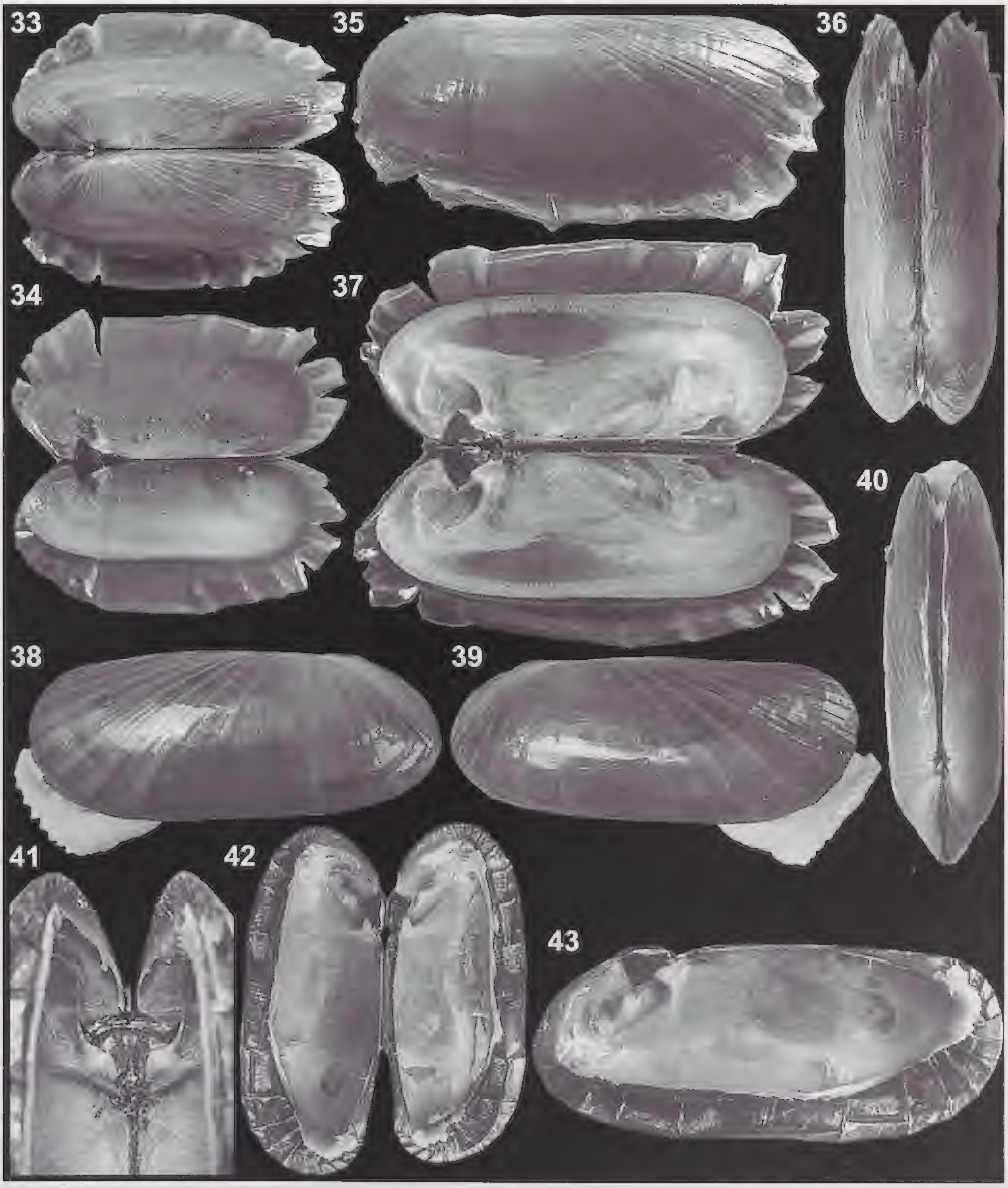
Interior: Ligament thick, subtriangular, broad, attached to chondrophore, without an expansion in front of chondrophore, visible externally as large, deep-brown, lozenge-shaped button behind beaks. Chondrophore strong, short, thin, oblique, bounding anterodorsal margin of posterior adductor scar, supported by a weak radial rib bounding anterior margin of posterior adductor scar. Anterior adductor scar large, angular-oval, feebly impressed. Posterior scar smaller, pear-shaped, well impressed, adjoining anteroventral margin of chondrophore, extending behind chondrophore; anterior end of posterior adductor scar impressed into inner shell surface, forming an arcuate cavity under chondrophore. Shell interior dull, with weak radial lines more conspicuous along ventral shell margin. Digestive tract present.

Comparisons

Solemya panamensis is most similar to *S. australis, S. pervernicosa,* and *S. parkinsonii* in the shell size, form, and proportions; but it easily differs from these species in the absence of an internal ligament expansion in front of the chondrophore (Table 2). Moreover, in contrast to *S. australis* (Figs. 88–94), this species has a thin chondrophore and a weak, narrow radial rib supporting the chondrophore. Unlike *S. parkinsonii* (Figs. 95–100), it has no posterior extensions of the resilium; its narrow internal radial rib supports the chondrophore; the an-



FIGS. 22–32. *Solemya (Petrasma) panamensis* (photos by P. Valentich-Scott). FIGS. 22–27: Holotype, exterior and interior views of left and right valves, ventral view of ligament and chondrophore of left and right valves, shell length 39.0 mm, Panama Bay (8°44'N, 79°09'W), Pacific Ocean, (USNM 110678); FIGS. 28–32: Gulf of Tehuantepec (15°37'00"N, 096°22'00"W), Oaxaca, Mexico, Pacific Ocean (SBMNH 83480); FIGS. 28–31: Exterior view of left and right valves, dorsal and ventral views of both valves, shell length 35.84 mm; FIG. 32: Ventral view of ligament and chondrophore, shell length 31.53 mm.



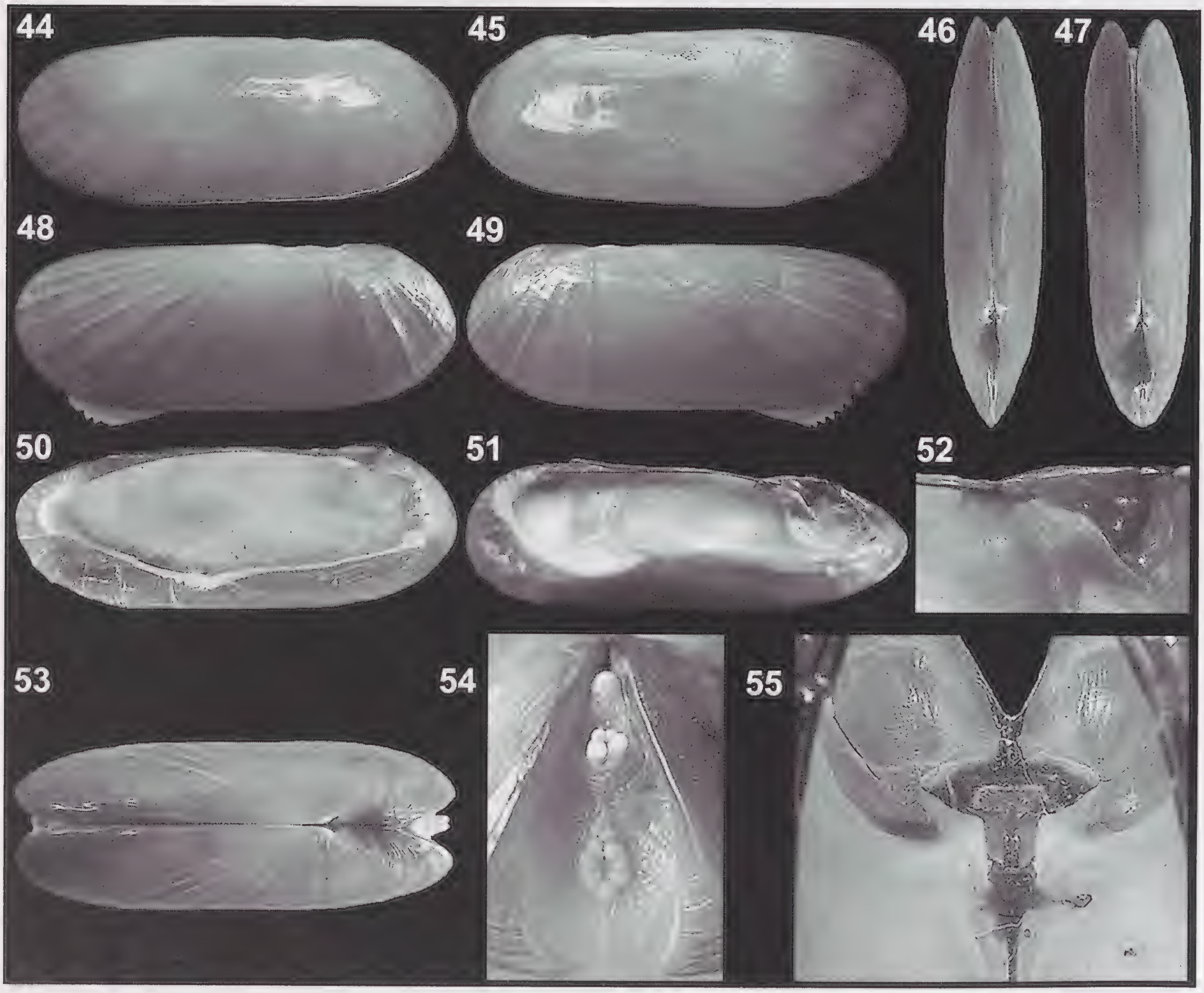
FIGS. 33–43. *Solemya (Petrasma) pervernicosa* from the northeastern Pacific. FIGS. 33, 34: Exterior and interior views of both valves, shell length 18.1 mm, Anthony Island (52°11.81'N, 131°15.10'W), Queen Charlotte Islands, British Columbia (RBCM 999-00210-012); FIGS. 35–37: Exterior view of right valve, dorsal and interior views of both valves, shell length 44.5 mm (RBCM 999-00210-012); FIGS. 38–43: Exterior view of left and right valves, dorsal view of both valves, ventral view of ligament and chondrophore, interior view of both valves and left valve, shell length 55.9 mm, Bawden Point, 75 m east (49°18.505'N, 126°00.320'W), Clayoquot Sound, Vancouver Island, British Columbia (MIMB 19964, donation by S. J. Lipovsky, CS).

terior end of the posterior adductor scar is impressed into the inner shell surface and adjoins the anteroventral margin of the chondrophore. In contrast to *S. pervernicosa* (Figs. 33–87), *S. panamensis* has a thin chondrophore and alimentary tract; internal radial rib supports the anterior end of chondrophore.

Solemya panamensis is further readily distinguished from *S. terraereginae* and *S. velesiana* by the lack of an internal ligament expansion in front of the chondrophore (Table 2). Unlike *S. pusilla, S. valvulus,* and *S. tagiri* which also have no internal ligament expansion in front of the chondrophore, *S. panamensis* lacks sharpened posterior extensions of the resilium; the chondrophore is supported by the radial rib; the anterior end of the posterior adductor scar is impressed into the inner shell surface and adjoins the anteroventral margin of the chondrophore.

Distribution and Habitat

Solemya (*Petrasma*) *panamensis* occurs from Panama Bay (8°44'N, 79°09'W) to Gulf of Tehuantepec, Oaxaca, Mexico (15°37'00"N, 096°22'00"W) (SBMNH 83480). The species has been recorded from 20 m to 235 m, on silt (Dall, 1908a; Bernard, 1983; P. Valentich-Scott, personal communication).



FIGS. 44–55. Young specimens of *Solemya (Petrasma) pervernicosa* from the northeastern Pacific. FIGS. 44–46: Exterior views of left and right valves, dorsal view of both valves, shell length 19.0 mm, Bawden Point, 75 m east (49°18.505'N, 126°00.320'W), Clayoquot Sound, Vancouver Island, British Columbia (MIMB 19964, donation by S. J. Lipovsky, CS); FIGS. 47–54: Specimens from Santa Monica Bay (33°55.70'N, 118°33.41'W), California (MIMB 19965, donation by T. Phillips, EMD); FIGS. 47–52: Dorsal view of both valves, exterior view of left and right valves, interior and ventral views of right valve, ventral view of ligament and chondrophore of right valve, shell length 22.5 mm; FIGS. 53, 54: Dorsal view of both valves, posterior aperture, shell length 24.6 mm; FIG. 55: Ventral view of ligament and chondrophore, Santa Monica Bay, California, shell length 35.0 mm (from Coan et al., 2000).

Solemya (*Petrasma*) *pervernicosa* Kuroda, 1948 (Figs. 33–87, Table 3)

Solemya (*Petrasma*) *pervernicosa* Kuroda, 1948: 32, figs. 4, 5; Kira, 1959: 194, pl. 71, fig. 3.
Petrasma pervernicosa (Kuroda, 1948) – Habe, 1977: 11; Habe, 1981: 25; Okutani et al., 1988: 21; Okutani, 2000: 833, pl. 414, fig. 4.
Petrasma pusilla (Gould, 1861) – Ito, 1985: 32, pl. 11, fig. 1.
Petrasma pervernicosa Kuroda, 1948 – Higo et al., 1999: 413.
Solemya reidi Bernard, 1980: 19–22, fig. 4; Bernard, 1983: 9; Valentich-Scott, 1998: 106–107, fig. 5.1; Coan et al., 2000: 65, pl. 1.
?*Petrasma atacama* Kuznetsov & Schileyko, 1984: 39–42, figs. 1, 2.

Type Material and Locality

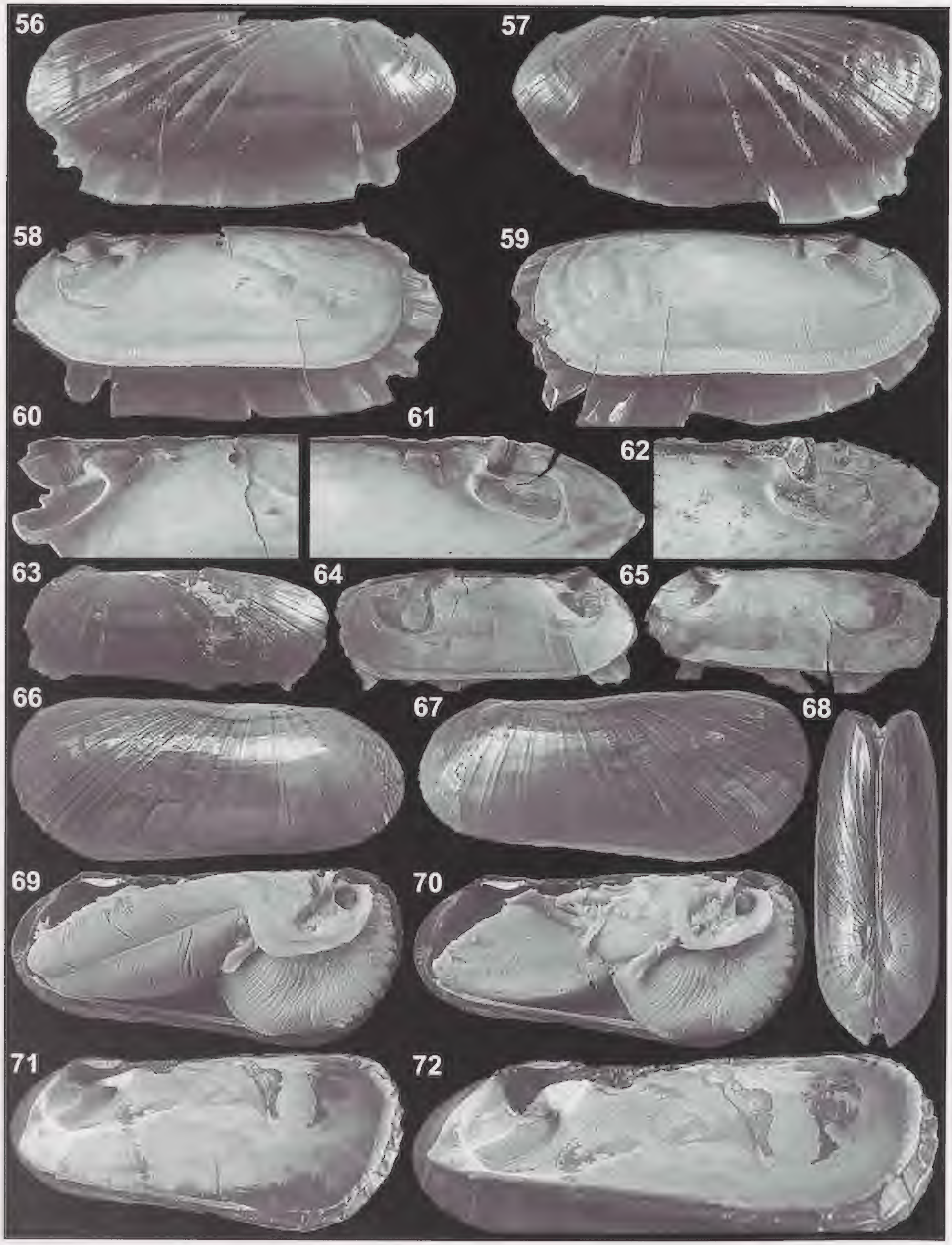
Solemya (*Petrasma*) *pervernicosa* – holotype (Nishinomiya Shell Museum, NC-H345), Cape Erimo, southeastern Hokkaido, 455 m (Kuroda, 1948; Higo et al., 1999; Hiroshi Saito (NSMT), personal communication); *Solemya reidi* – holotype (National Museum of Canada, 86074), Texada Island, northern Strait of Georgia, British Columbia, Canada (49°4'N, 124°33.2'W), 326 m (Bernard, 1980); *Petrasma atacama* – neither type or any other materials have not been found (IO RAS, ZMMU), near the Peru-Chile Trench (7°41'S, 79°47'W), 105 m (Kuznetsov & Schileyko, 1984).

Material Examined

One specimen (MIMB 19962), Sakhalin Island (46°51'N, 143°58.7'E – 47°02'N, 143°48.5'E), Sea of Okhotsk, 300–800 m, Coll. A. A. Balanov, 22.07.1997; Shell fragments of two specimens (IMB 19963), Tatar Strait, Sakhalin Island (48°20.9'N, 141°27.8'E – 48°29.2'N, 141°27.9'E), Sea of Japan, 330 m, Coll. G. M. Kamenev, 11.11.2003; 4 specimens (IO RAS), near the Peru-Chile Trench

TABLE 3. *Solemya (Petrasma) pervernicosa.* Shell measurements (mm), indices and summary statistics: L – shell length (without periostracum); H – height; A – anterior end length.

Area	L	H	A	H/L	A/L
Chiba Prefecture, Japan (NSMT Mo 76720)	60.0	21.0	39.0	0.350	0.650
Chiba Prefecture, Japan (NSMT Mo 76720)	43.0	16.0	29.0	0.372	0.674
Chiba Prefecture, Japan (NSMT Mo 76720)	50.0	18.0	35.0	0.360	0.700
Sakhalin Island, Sea of Okhotsk	63.1	24.5	41.1	0.388	0.651
Anthony Island, Queen Charlotte Islands, British Columbia (RBCM 999-00210-012)	44.5	17.0	31.0	0.382	0.697
Anthony Island, Queen Charlotte Islands, British Columbia (RBCM 999-00210-012)	21.4	8.5	15.3	0.397	0.715
Anthony Island, Queen Charlotte Islands, British Columbia (RBCM 999-00210-012)	18.1	6.2	12.6	0.343	0.696
Clayoquot Sound, Vancouver Island, British Columbia	55.9	21.8	34.2	0.390	0.612
Clayoquot Sound, Vancouver Island, British Columbia	19.0	7.5	12.1	0.395	0.637
Clayoquot Sound, Vancouver Island, British Columbia	3.8	1.6	2.7	0.421	0.711
Santa Monica Bay (33°54.45'N, 118º31.46'W), California	24.6	9.0	16.1	0.365	0.654
Santa Monica Bay (33°54.45'N, 118º31.46'W), California	22.5	8.4	14.8	0.373	0.658
Santa Monica Bay (33°55.70'N, 118º33.41'W), California	16.3	5.8	10.8	0.356	0.663
Mean	-	-	-	0.376	0.671
SE	-	-	-	0.006	0.009
SD	-	-	-	0.022	0.031
Min	3.8	1.6	2.7	0.343	0.612
Max	63.1	24.5	41.1	0.421	0.715
N	13	13	13	13	13



FIGS. 56–72. *Solemya (Petrasma) pervernicosa* from the northwestern Pacific. FIGS. 56–65: Specimens from Loc. Choshi, Chiba Prefecture, Japan (NSMT Mo 76720); FIGS. 56–61: Exterior and interior views and ventral view of ligament and chondrophore of left and right valves, shell length 58.0 mm; FIG. 62: Ventral view of ligament and chondrophore of right valve, shell length 50.0 mm; FIGS. 63–65: Exterior view of right valve, interior view of right and left valves, shell length 43.0 mm; FIGS. 66–72: Specimen from Sakhalin Island (46°51'N, 143°58.7'E – 47°02'N, 143°48.5'E), Sea of Okhotsk (MIMB 19962), exterior views of left and right valves, dorsal view of both valves, right side after removal of right valve and mantle, right side after removal of right valve, mantle, and gill, interior and ventral views of left valve, shell length 63.1 mm.

(5°57'S, 81°15.7'W), Pacific Ocean, 330 m, clayey silt, R/V "Akademik Kurchatov"(cruise 4), 4.11.1968; *P. pervernicosa* – 3 specimens (NSMT Mo 76720), Loc. Choshi, Chiba Prefecture, Japan; *S. reidi* – 3 specimens (RBCM 999-00210-012), Anthony Island (52°11.81'N, 131°15.10'W), Queen Charlotte Islands, British Columbia, Canada, 63.5 m, Coll. P. Lambert, 17.06.1999; 1 specimen (RBCM 001-00126-002), Montagu Channel, Canada, 14.02.1977; 3 specimens (MIMB 19964, donation by S. J. Lipovsky, CS), Bawden Point, 75 m east (49°18.505'N, 126°00.320'W), Clayoquot Sound, Vancouver Island, British Columbia, Canada, 101 m, Coll. B. Taekema, 30.05.2006; 2 specimens (MIMB 19965, donation by T. Phillips, EMD), Santa Monica Bay (33°54.45'N, 118°31.46'W), California, 60 m, Coll. T. Phillips, 31.07.2006; 1 specimen (MIMB 19966, donation by T. Phillips, EMD), Santa Monica Bay (33°55.70'N, 118°33.41'W), California, 156 m, Coll. T. Phillips, 10.07.2006. Total of 18 specimens and shell fragments of 2 specimens.

Description (expanded from Bernard, 1980)

Exterior: Shell large (to 65 mm), elongate-oval (H/L = 0.343–0.421), moderately inflated, equivalve, strongly inequilateral, thin, flexible, poorly mineralized (dry shell very fragile), white under periostracum, gaping anteriorly. Sculpture of very low, broad, widely spaced radial ribs, less expressed and often absent medially, and narrow, radial, thread-like ribs in space between broad ribs of anterior shell end. Periostracum thick, dark chestnut-brown, with a black oval or elongate-oval spot in umbonal area, widely extending beyond shell margin. Beaks very small, obscure, not prominent, near posterior end (A/L = 0.612–0.715), situated in front of black, uncalcified area of shell covering a lateral expansion of internal ligament. Posterior shell end rounded, slightly angular. Anterior end broadly rounded. Posterodorsal shell margin slightly convex in internal ligament area, forming a small, smooth, obtuse angle, smoothly transitioning to slightly angular posterior margin. Anterodorsal shell margin straight, parallel to ventral margin, smoothly transitioning to rounded anterior margin. Ventral margin straight.

Interior: Ligament thick, strong, subtriangular, attached to chondrophore, with an oval or elongate-oval expansion (often irregular in form and extending along dorsal margin) in front of chondrophore. Chondrophore very strong, short, oblique, bounding anterodorsal margin of posterior adductor scar, supported by a weak, low, radial rib bounding anterior margin of posterior adductor scar. Anterior adductor scar large, angular-oval, feebly impressed. Posterior scar smaller, pear-shaped, well impressed, adjoining anteroventral margin of chondrophore, extending behind chondrophore; anterior end of posterior adductor scar impressed into inner shell surface and adjoining anteroventral margin of chondrophore forming an arcuate cavity under chondrophore. Shell interior dull, with weak radial lines more conspicuous along ventral shell margin. Posterior aperture of young specimens with a large, dorsal papilla, two pairs of suprasiphonal papillae (ventral pair longer and thicker), and 12 siphonal papillae increasing in size ventrally. Digestive tract absent.

Variability

Shell shape and proportions vary slightly (Figs. 33–87, Table 3). The width and number of radial ribs, especially in the posterior shell end, are also slightly variable. In young specimens, the radial ribs in the anterior and posterior ends of shell are more noticeable (Figs. 33, 44–49, 77, 78), the color of the periostracum is markedly lighter, bright brown, sometimes with a reddish hue or more uniform. Form of the external, black uncalcified spot in the umbonal area markedly varies. In young specimens, this spot is distinctly diamond-shaped or triangular and is situated just behind the beaks (Figs. 46, 47, 53, 79, 85). In adults, the relative size and form of this spot greatly vary from weakly visible, small, rounded to large, bright black, elongate-oval (Figs. 36, 40, 68). Correspondingly, highly variable are the relative size, width, and form of the internal expansion of the ligament in front of the chondrophore (Figs. 37, 41, 55, 60–62, 72). The posterior scar in adults varies from rounded-elongate, pear-shaped (Figs. 43, 58, 59, 71) to angular, trigonal-rounded, with an acute angle between the dorsal and anterior margins of the scar (Fig. 37).

Distribution and Habitat

Solemya (*Solemya*) *pervernicosa* occurs in the western Pacific off Japan from the Kii Peninsula (Honshu, Pacific Ocean) to Cape Erimo (Hokkaido, Pacific Ocean) (Habe, 1981; Okutani et al., 1988; Higo et al., 1999; Okutani, 2000), off Kuriya, Awa Island (Sea of Japan) (Ito, 1985; Okutani et al., 1988), off western Sakhalin Island (Tatar Strait, Sea of Japan), off southeastern Sakhalin Island (Sea of Okhotsk); in the eastern Pacific from southeast Alaska (58°N) to Peru (7°41'S) (Bernard, 1980, 1983; Kuznetsov & Schileyko, 1984; Valentich-Scott, 1998; Coan et al., 2000). This species has been recorded at depths from 40 to 1510 m (Sagami Bay, Japan) in areas of high organic content and low oxygen levels (Okutani et al., 1988; Valentich-Scott, 1998; Coan et al., 2000; Okutani, 2000).

Comparisons

Solemya pervernicosa is readily distinguished from the Pacific species *S. valvulus*, *S. pusilla*, and *S. tagiri*, by the presence of an internal expansion of the ligament in front of the chondrophore and a radial rib supporting the chondrophore and bounding the anterior margin of the posterior adductor scar (Table 2). Likewise, it readily differs from *S. terraereginae, S. velesiana,* and *S. moretonensis* in the shapes of the resilium and chondrophore, and the ligament expansion in front of chondrophore.

Solemya pervernicosa is most similar to *S. australis, S. panamensis,* and *S. parkinsonii* in the shell size, form, and proportions; but it easily differs from these species in the shape of the internal ligament expansion, the position and appearance of the radial rib supporting the chondrophore, as well as the shape and position of the chondrophore and the posterior adductor scar.

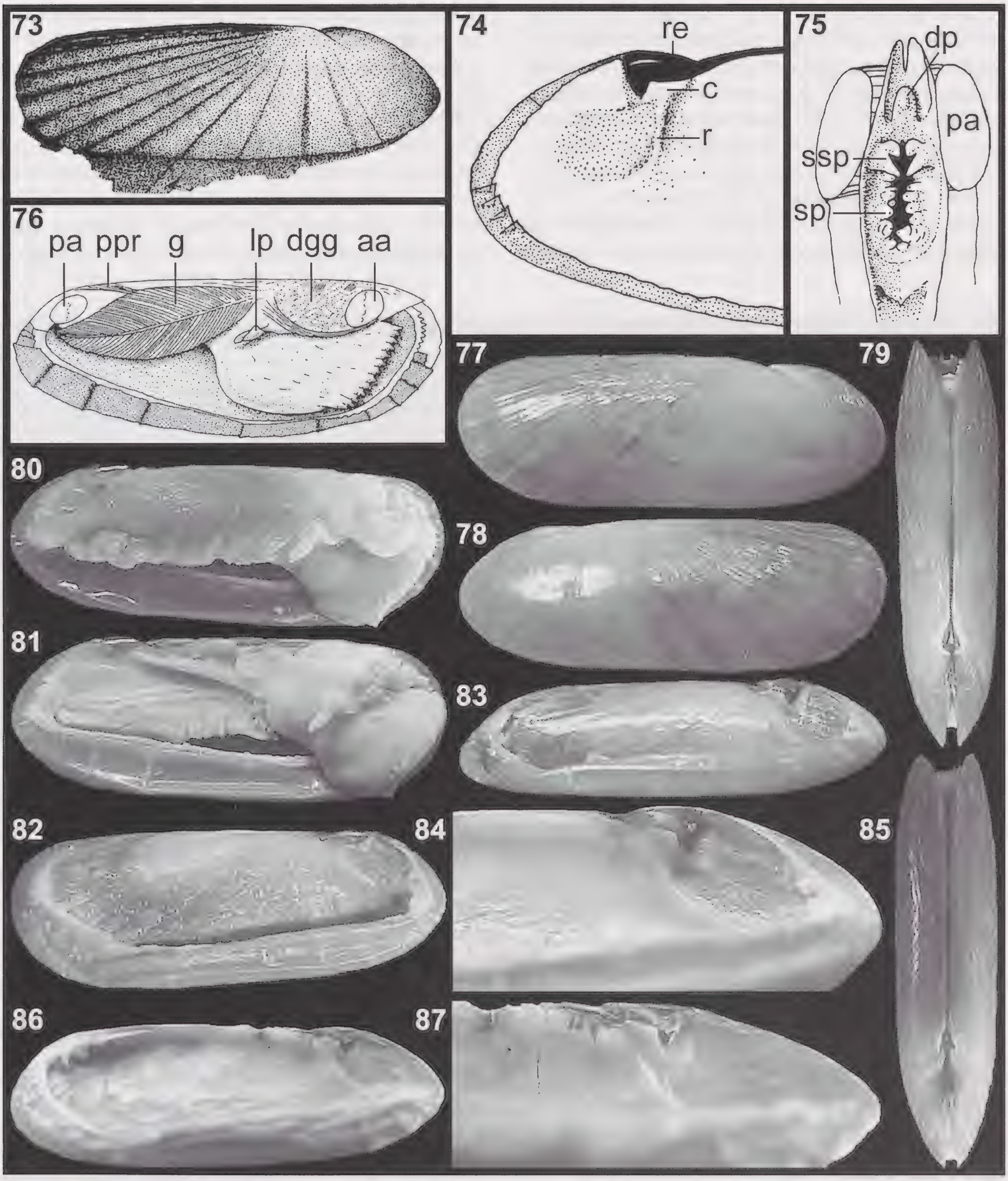
Solemya pervernicosa primarily differs from *S. panamensis* in the presence of an expansion of the ligament in front of the chondrophore, the lack of alimentary canal, and in having a stronger and thicker chondrophore with a radial rib supporting the posterior, but not the anterior end of the chondrophore (Figs. 23, 26, 37, 43, 58, 59, 71).

In *S. australis* (Figs. 88–94), unlike *S. pervernicosa*, the internal ligament expansion looks like two large oval lobes that are positioned in a shallow depression on the inner shell surface. To these lobes corresponds a short, black or gray stria on the outer surface of the shell in the umbonal area that crosses the dorsal shell margin at a straight angle. The interior radial rib that supports the chondrophore is strong, well expressed, broad, projecting above the inner shell surface as a ridge in front of the posterior adductor scar. In contrast to *S. pervernicosa*, this rib supports the anterior, but not the posterior end of the chondrophore, and touches the internal lobes of the ligament. Moreover, the posterior adductor scar is not impressed into the inner shell surface; the chondrophore is short and narrowed posteriorly.

In *S. parkinsonii* (Figs. 95–100), in comparison with *S. pervernicosa*, the internal expansion of the ligament extends laterally as well-marked, narrow, long striae, which are also visible on the external shell surface. These striae of the ligament are situated in the corresponding furrows on the inner surface of the shell. The chondrophore is long, thin, thickening posteriorly, and not supported by a radial rib. Weakly expressed radial ribs on the inner shell surface appear as broad, low, rounded ridges extending ventrally from the dorsal shell margin between the chondrophore and lateral striae of the ligament. The posterior adductor scar is small, rounded-triangular, not adjoining the chondrophore.

Remarks

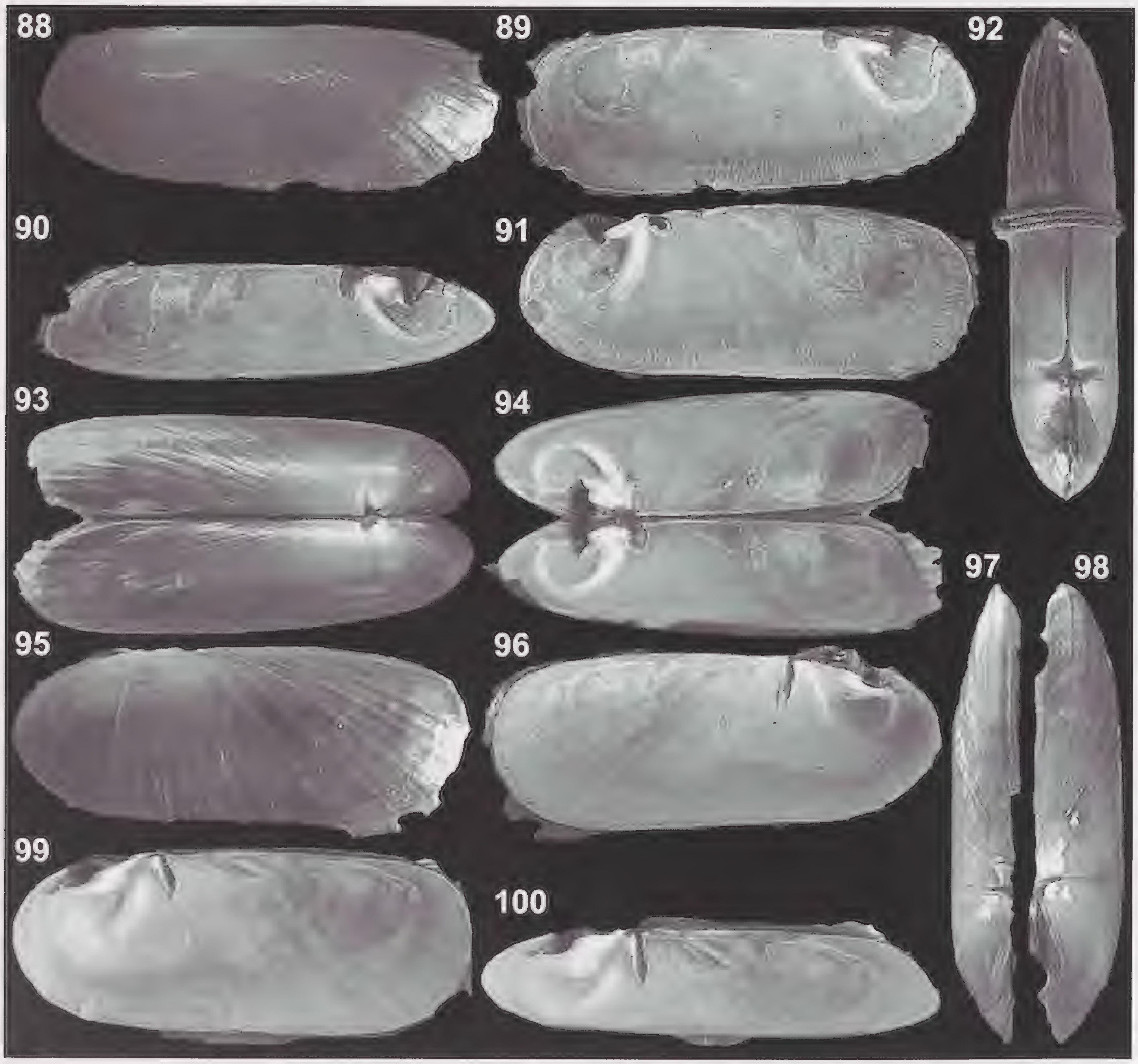
The study of *Solemya* species from the Pacific seas of Russia, as well as *S. reidi* from the northeastern Pacific showed that these species are identical to *S. pervernicosa*. In the description of *S. reidi*, Bernard (1980) made a detailed comparison of this species with other species of the genus *Solemya*. Unfortunately, he did not compare *S. reidi* with the large, well-identifiable *S. pervernicosa* found off Japan. Indeed, these species are similar in size, shape, proportions, and external and internal shell morphology (Figs. 33–43, 56–72, Table 3). Both species have a dark chestnut-brown periostracum, an identical shell sculpture of broad, low, widely spaced radial ribs and very fine radial ribs in the space between broad ribs, and a strong, subtriangular internal ligament attached to oblique, strong chondrophore. The chondrophore is supported by a radial rib bounding the anterior margin of the posterior adductor scar. This rib is weakly expressed and is mostly formed by the deeply impressed posterior adductor scar. The form and arrangement of the anterior and posterior adductor scars, taking into account their individual variability, are also identical. The two species have an internal expansion of the ligament in front of the chondrophore. The form of this expansion varies markedly. In adult specimens of *S. reidi* from British Columbia and California, this ligament expansion appears as well noticeable, fairly thick, rounded lateral patches, or it is oval with short lateral rays of varying length (Figs. 37, 41). In young specimens of *S. reidi*, the form of this expansion is also variable (Figs. 34, 51, 52, 55). A specimen from the southern Sea of Okhotsk has a thick,



FIGS. 73–87. *Solemya (Petrasma) pervernicosa* from the southeastern Pacific. FIGS. 73–76: *Petrasma atacama*, holotype, exterior view of left valve, interior view of ligament and chondrophore of left valve, posterior aperture, right side after removal of right valve and mantle, shell length 14.0 mm, Peru-Chile Trench (5°57'S, 81°15.7'W) (from Kuznetsov & Schileyko, 1984, figs. 1A, 2A, B, C); FIGS. 77–87: Peru-Chile Trench (5°57'S, 81°15.7'W), Pacific Ocean (IO RAS). FIGS. 77–84: External view of left and right valves, dorsal view of both valves, right side after removal of right valve and mantle, right side after removal of right valve, mantle, and gill, interior and ventral views of right valve, ventral view of ligament and chondrophore of right valve, shell length 25.0 mm; FIG. 85: Dorsal view of both valves, shell length 23.7 mm; FIGS. 86–87: Ventral view of right valve, ventral view of ligament and chondrophore of right valve, shell length 19.7 mm. aa, anterior adductor muscle; c, chondrophore; dgg, digestive gland and gonad; dp, dorsal papilla; g, gill; lp, labial palp; pa, posterior adductor muscle; ppr, posterior pedal retractor muscle; r, radial rib in front of posterior adductor scar; re, resilium; sp, siphonal papillae; ssp, suprasiphonal papillae.

knob-like, oval expansion of the ligament (Figs. 71, 72). In *S. pervernicosa* from the Pacific waters of Honshu, Japan, the internal expansion of the ligament is less expressed, thin, elongate, extending along the dorsal margin, sometimes with sparse, short lateral rays (Figs. 60–62). My opinion is that this difference in the form of the internal ligament expansion in front of the chondrophore, taking into account its individual variability, is not a specific characteristic. Therefore, I consider *S. reidi* to be a synonym of *S. pervernicosa*.

Kuznetsov & Schileyko (1984) described *Petrasma atacama* Kusnetzov & Schileyko, 1984, on the basis of material from the eastern Pacific (Figs. 73–76). Unfortunately, my attempts to find any original material of this species in the collections of IO RAS and ZMMU were unsuccessful. *Petrasma atacama* was described by Kuznetsov & Schileyko (1984)



FIGS. 88–100. *Solemya (Austrosolemya) australis* and *Solemya (Zesolemya) parkinsonii*. FIGS. 88–94: *Solemya (Austrosolemya) australis*, Spencer Gulf (34°0.000'S, 137°0.000'E), South Australia (AMS C 458812); FIGS. 88–90: External, internal, and ventral views of right valve, shell length 50.0 mm; FIG. 91: Internal view of left valve, shell length 44.0 mm; FIGS. 92–94: *Solemya (Austrosolemya) australis*, 35°15.000'S, 137°0.000'E, South Australia (AMS C 085088); FIG. 92: Dorsal view of both valves, shell length 38.0 mm; FIGS. 93, 94: External and internal views of both valves, shell length 45.0 mm; FIGS. 95–100: *Solemya (Zesolemya) parkinsonii*, external and internal views of right valve, dorsal view of left and right valves, internal and ventral views of left valve, shell length 35.5 mm, N Douglas, Auckland, Tamaki Strait, Kawaka Bay, North Island, New Zealand (NMNZ M 274993).

from nine specimens. The authors designated a holotype and three paratypes, provided shell measurements of the holotype (the largest specimen: L = 14.0 mm, H = 5.7 mm, W = 3.0 mm), and described the shell morphology and anatomy of this species. However, there was no indication whether the lateral expansion of the ligament and the corresponding uncalcified area of the shell in the umbonal area are present or lacking. Since it was assigned to the genus *Petrasma*, this species presumably had no internal lateral expansion of the ligament. *Petrasma atacama* was only compared by the authors with *S. valvulus*, from which it primarily differed in the presence of the radial rib supporting the chondrophore and the lack of alimentary canal. Because of the insufficiently complete description and comparative analysis of this species, a number of authors repeatedly noted that *P. atacama* requires a more detailed study and comparison with the closest species *S. reidi* and *S. panamensis* (Valentich-Scott, 1998; Coan et al., 2000). Judging from its description, *S. atacama* is identical in shell morphology to *S. panamensis* (Figs. 22, 25, 28, 29, 73); however, it differs from the latter species in the lack of alimentary canal (Bernard, 1980; Kuznetsov & Schileyko, 1984). This species is also close to *S. pervernicosa*. They have the same structure of the chondrophore and similar features of the posterior aperture (Figs. 54, 75) and lack the alimentary canal. However, *P. atacama*, unlike *S. pervernicosa*, have no lateral expansion of the ligament in front of the chondrophore. *Petrasma atacama* was represented by small specimens, in which this feature is usually weakly expressed, as, for example, in the investigated young specimens of *S. pervernicosa* with a shell length of 16 to 25 mm (Figs. 34, 51, 52). It is possible that the authors describing this species paid no attention to this poorly visible feature. Therefore, I think it is likely that *P. atacama* was described from the young specimens of *S. pervernicosa*.

A revision of the entire bivalve collection of the IO RAS revealed four specimens of a species of *Solemya*, with a shell length of 19.4–25.0 mm (Figs. 77–87), which were collected near the Peru-Chile Trench (5°57'S, 81°15.7'W), at the 330 m depth, relatively near the area where the *P. atacama* material was sampled.

These specimens of *Solemya* species may relate to *P. atacama* because they are very similar in proportions and the external morphology of the shell. Furthermore, this *Solemya* species also lacks an alimentary canal. However, in contrast to *P. atacama*, it has the internal expansion of the ligament in front of the chondrophore (Figs. 84, 87). This species is most similar to *S. pervernicosa*. Unlike the similar-sized specimens of *S. pervernicosa*, it has a more elongate shell (H/L = 0.304–0.350), a more pointed posterior end, finer posterior ribs, and a thinner chondrophore (Figs. 77, 78, 82–84). Possibly, these differences are due to the individual variability of *S. pervernicosa*, therefore, I assume that this *Solemya* species is probably *S. pervernicosa*.

It is well known that the different species of the genus *Solemya* harbor symbiotic sulfur-oxidizing chemoautotrophic bacteria, on which they depend to varying degrees. This leads to the reduction or loss of the gut (Reid, 1980; Doeller, 1984; Kuznetsov & Schileyko, 1984; Doeller et al., 1988; Kuznetsov et al., 1990; Krueger et al., 1996a, b; Okutani et al., 2003). Solemyid bivalves thrive in sediments with high loads of organic matter, hydrogen sulfide, and low concentration of oxygen. They were also found at methane cold seeps and in sediments influenced by hydrothermal venting (Sibuet & Olu, 1998; Okutani et al., 2003).

Solemya pervernicosa is a typical chemoautotrophic species, which is highly specialized for chemoautotrophic nutrition. It has endosymbiotic chemoautotrophic bacteria and completely lacks an alimentary canal (Bernard, 1980; Reid, 1980; Felbeck, 1983; Fisher & Childress, 1984, 1986; Powell & Somero, 1985; Anderson et al., 1987, 1990; Lee et al., 1992; Wilmot & Vetter, 1992). In the northeastern Pacific, this species is frequently found in areas of sewage outfalls or with abundant woody debris, which are highly enriched in organics, low in oxygen, and high in hydrogen sulfide (Reid, 1980; Valentich-Scott, 1998; Coan et al., 2000). In the northwestern Pacific, it was recorded in cold seeps areas. Off Japan, this species was found at the 1,510 m depth in Sagami Bay (Okutani et al., 1988; Okutani, 2000), where deep water is characterized by the abundance of methane seeps supporting dense aggregations of various chemoautotrophic bivalves (Okutani, 1957, 1962; Okutani & Egawa, 1985; Kojima & Ohta, 1997; Kamenev et al., 2001). In the Sea of Okhotsk, *S. pervernicosa* was found on the southeastern Sakhalin slope, where methane seeps also exist (Obzhirov, 1993). A chemoautotrophic thyasirid species, *Conchocele bisecta* (Conrad, 1849), was earlier found in almost the same area (Kamenev et al., 2001). A large number of active seeps of free methane or methane-rich fluids with gas hydrates have been reported to exist in the bottom sediments of the eastern Sakhalin slope and on the sea floor of the Derugin Basin (Obzhirov, 1993; Biebow & Hütten, 1999; Greinert et al., 2002; Sahling et al., 2003; Obzhirov et al., 2007). Numerous chemoautotrophic bivalves *Calyptogena rectimargo* Scarlato, 1981, *C. bisecta*, *Acharax* sp., pogonophoran tube worms, and bacterial mats are associated with methane seeps areas off eastern Sakhalin (Kamenev, 2001; Sahling et al., 2003; Krylova & Sahling, 2006). Cold-water methane-rich seep zones are fairly widely distributed in the Sea of Okhotsk (Avdeiko et al., 1984; Obzhirov, 1993; Gaedicke et al., 1997; Obzhirov et al., 2007). It is therefore quite likely that *S. pervernicosa* will be found in many of them.

Genus *Acharax* Dall, 1908

Type species – *Solemya johnsoni* Dall, 1891, by original designation.

Diagnosis

Shell moderately thick, poorly mineralized, elongate-oval, compressed, inequilateral, equivalve. Beaks obscure, not prominent, strongly posterior. Periostracum thick, adherent, varnished, extending beyond shell. Surface with widely spaced radial ribs. Lunule and escutcheon absent. Ligament opisthodetic, external, seated on a narrow nymph. Chondrophore absent. Hinge plate weak, edentate. Adductor scars unequal; posterior scar small and impressed; anterior scar large.

The genus contains 11 living species.

Acharax johnsoni (Dall, 1891)
(Figs. 101–108)

Solemya johnsoni Dall, 1891: 189.
Acharax johnsoni Dall, 1891 – Kafanov & Lutaenko, 1997: 156, 157, fig. 1, synonymy.
Acharax johnsoni (Dall, 1891) – Coan et al., 2000: 66, pl. 1, synonymy.

Type Material and Locality

Holotype (United States National Museum, No. 106886), Baja California Norte, 1,840 m, Holocene, “Albatross” (Kafanov & Lutaenko, 1997).

Material Examined

Two specimens (IO RAS), Sakhalin Island (54°28’N, 145°21’E), Sea of Okhotsk, 1,451 m, RV “Vityaz” (cruise 2, station 103), 13.09.1949; Shell fragments of one specimen (IO RAS), Sakhalin Island (54°00.5’N, 146°17’E), Sea of Okhotsk, 1,515–1,486 m, RV “Akademik Lavrentyev”, Coll. S. V. Galkin, 20.08.1998; 3 specimens (IO RAS), Monterey Canyon (36°35.4’N, 122°30.5’W), Pacific Ocean, 3,040 m, RV “Akademik Mstislav Keldysh” (cruise 22, underwater vehicle “Mir-1”, diving 17/61), Coll. L. I. Moskalev, 21-22.09.1990; 1 specimen (IO RAS), Peru-Chile Trench (2°00.0’S, 81°31’W), Pacific Ocean, 3,840–3,200 m, RV “Akademik Kurchatov” (cruise 4, station 305), Coll. L. I. Moskalev, 07.11.1968; Shell fragments of one specimen (IO RAS), Peru-Chile Trench (8°29.3’S, 80°46.1’W), Pacific Ocean, 4,200 m, RV “Akademik Kurchatov” (cruise 4, station 292), Coll. L. I. Moskalev, 30-31.10.1968; Shell fragments of one specimen (IO RAS), Peru-Chile Trench (12°27.8’S, 78°34.9’W), Pacific Ocean, 4,200 m, RV “Akademik Kurchatov” (cruise 4, station 277), Coll. L. I. Moskalev, 25.10.1968. Total of 6 specimens and shell fragments of 3 specimens.

Diagnosis

Shell large (to 150 mm), elongate-oval, moderately inflated, equivalve, strongly inequilateral, thick, friable. Sculpture of low, broad, widely spaced radial ribs. Periostracum thick, deep-brown to black, widely extending beyond shell margin. Beaks small, not prominent, strongly posterior. Posterior shell end rounded, narrowed. Anterior shell end truncated. Ligament opisthodetic, external, thick, attached to a nymph. Anterior adductor scar large, feebly impressed. Posterior scar smaller, well impressed. Shell interior dull, with noticeable radial ribs at anterior end, corresponding to external shell sculpture.

Remarks

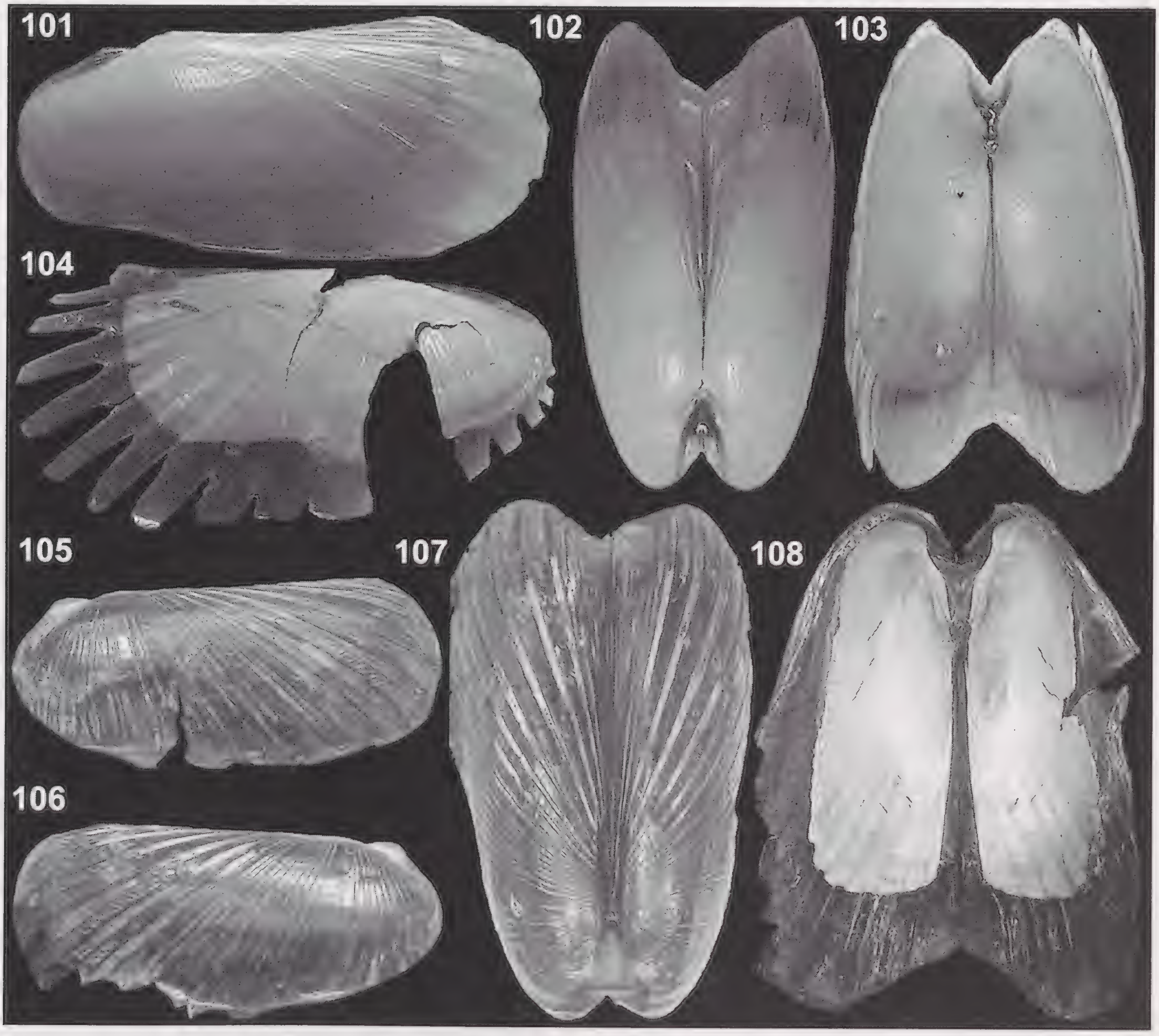
Shell morphology of all the investigated specimens and fragments of *Acharax* from the collection of the IO RAS corresponds to the diagnosis of *A. johnsoni*. Therefore, I think that all this material can be referred to *A. johnsoni.*

Until recently, it has been believed that only one species *A. johnsoni* occurs in the eastern Pacific from Alaska to Peru (Coan et al., 2000). However, genetic studies of the *Acharax* material from different areas of the Pacific and Indian Oceans showed that in the eastern Pacific there are most probably two distinct species, which, despite their morphological similarity, well separate genetically (Neulinger et al., 2006).

At present, six species of *Acharax* are known in the Pacific Ocean: *A. johnsoni; A. japonica; Acharax bartschii* Dall, 1908; *Acharax alinae* Métivier & von Cosel, 1993; *Acharax clarificata* Dell, 1995; and *Acharax patagonica* (Smith, 1885) (Dall, 1908b; Métivier & von Cosel, 1993; Dell, 1995; Coan et al., 2000; Okutani, 2000; Osorio & Reid, 2004). Most of these species are very similar in shell morphology. It is therefore no wonder that Neulinger et al. (2006), when studying the *Acharax* material from the vast region of the eastern Pacific ranging from the Aleutian Islands to Peru, revealed two species that were previously identified as one, *A. johnsoni.* The genetically studied material of *Acharax* is now deposited in the Santa Barbara Museum of Natural History (USA) (Neulinger et al., 2006; P. Valentich-Scott, personal communication). It is possible that a more thorough examination of this material will help to separate these species on the basis of shell morphology or anatomy.

Distribution and Habitat in the Pacific Ocean

Acharax johnsoni occurs in the eastern Pacific from Sitka, Alaska (57.1°N) (Coan et al., 2000) to Lima, Peru, (Peru-Chile Trench, 12°27.8'S, 78°34.9'W); in western Pacific from



FIGS. 101–108. *Acharax johnsoni*. FIGS. 101–104: Sakhalin Island (54°28'N, 145°21'E), Sea of Okhotsk, 1451 m (IO RAS); FIGS. 101–103: Exterior view of right valve, dorsal and ventral views of both valves of young specimen, shell length 19.0 mm; FIG. 104: Exterior view of left valve, shell length 43.0 mm; FIGS. 105–108: Monterey Canyon (36°35.4'N, 122°30.5'W), Pacific Ocean, 3,040 m (IO RAS), exterior view of right and left valve, dorsal and ventral views of both valves, shell length 108.0 mm.

Cape Olyutorskiy, Bering Sea (60°N) (Kafanov & Lutaenko, 1997) and northeastern Sakhalin Island, Sea of Okhotsk (54°28'N, 145°21'E) to Tosa Bay, Honshu, Japan (Higo et al., 1999). This species was recorded at depths from 100 to 5,379 m (Japan Trench, 39°06.47'N, 143°53.49'E) (Habe, 1977; Okutani, 2000; Fujikura et al., 2002; Okutani & Fujikura, 2002), on silt and clayey silt often in areas of methane seeps (Fujikura et al., 2002; Okutani & Fujikura, 2002; Fujiwara, 2003; Neulinger et al., 2006).

Remarks

In the eastern Pacific, one shell fragment of a large specimen of *Acharax* sp. was found much farther south of Lima, in the deep-sea methane seeps area off Conception, Chile (depth 934 m, 36°21.46'S, 73°44.08'W) (Sellanes et al., 2004). This shell fragment may be *A. johnsoni*. Hence, it can be assumed that in the eastern Pacific this species occurs farther south of the area of Peru-Chile Trench off Lima, Peru.

Like the species of *Solemya, A. johnsoni* harbors endosymbiotic chemoautotrophic bacteria in its gills (Fujiwara, 2003; Imhoff et al., 2003; Neulinger et al., 2006). Therefore, this species is often encountered in areas of cold methane-rich fluids and methane seeps (Fujikura et al., 2002; Okutani & Fujikura, 2002; Fujiwara, 2003; Imhoff et al., 2003; Sellanes et al., 2004; Neulinger et al., 2006). In Monterey Canyon, it was recorded in cold gas seeps areas, on a silty bottom dominated by the bivalve *Ectenagena extenta* Krylova & Moskalev, 1996 (Krylova & Moskalev, 1996). In the Sea of Okhotsk, *A. johnsoni* was found off northeastern Sakhalin Island at depths from 370 to 1,515 m in areas of methane-rich fluids and methane seepage, which support a rich fauna of chemoautotrophic species of bivalve mollusks and pogonophoran tubeworms (Kamenev et al., 2001; Sahling et al., 2003).

ACKNOWLEDGMENTS

I am very grateful to Drs. A. V. Gebruk, E. M. Krylova, L. I. Moskalev, T. N. Molodtsova, and all collaborators of Laboratory of Ocean Bottom Fauna (IO RAS), as well as to Ms. I. Volvenko (ZMU) for arrangement of my work with the bivalve mollusk collections at the IO RAS and ZMU and great help during this work; to Drs. H. Saito (NSMT), B. A. Marshall (NMNZ), I. Loch and A. Miller (AMS), T. Phillips (EMD), S. J. Lipovsky (CS), K. Sendall (RBCM), Mr. Paul Valentich-Scott (Department of Invertabrate Zoology, SBMNH) for sending specimens of *Solemya* species; to Drs. B. A. Marshall, E. V. Coan (Department of Invertebrate Zoology, California Academy of Sciences, San Francisco), P. G. Oliver (NMW), J. D. Taylor (Department of Zoology, Natural History Museum, London) and Mr. P. Valentich-Scott for the consultations and for sending copies of scientific papers necessary for this work; to P. Valentich-Scott, A. J. Baldinger (MCZ), and Dr. P. G. Oliver for sending photos of *Solemya* species; to Ms. T. N. Koznova (IMB) for help with translating the manuscript into English; to Dr. G. M. Davis (George Washington University, Washington, D.C.) for help in the publication of manuscript; to Drs. E. M. Krylova, G. Paulay, E. V. Coan, and anonymous reviewer for comments on the manuscript.

This research was partly supported by the Far Eastern Branch of the Russian Academy of Sciences (grant no. 09-III-A-06-203).

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Revised ms. accepted 25 December 2008